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DESCRIPTION AND TEST OF A FISHING TRAWL AND NET RESISTANT BOTTO--ETC(U)

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FINAL REPORT

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DESCRIPTION AND TEST OF A FISHING TRAWL  
AND NET RESISTANT BOTTOM MOUNTED CURRENT  
METER, WITH DIVERLESS SURFACE DEPLOYMENT  
AND RECOVERY CAPABILITIES,

by

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WOODS HOLE OCEANOGRAPHIC INSTITUTION  
Woods Hole, Massachusetts 02543

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TECHNICAL REPORT

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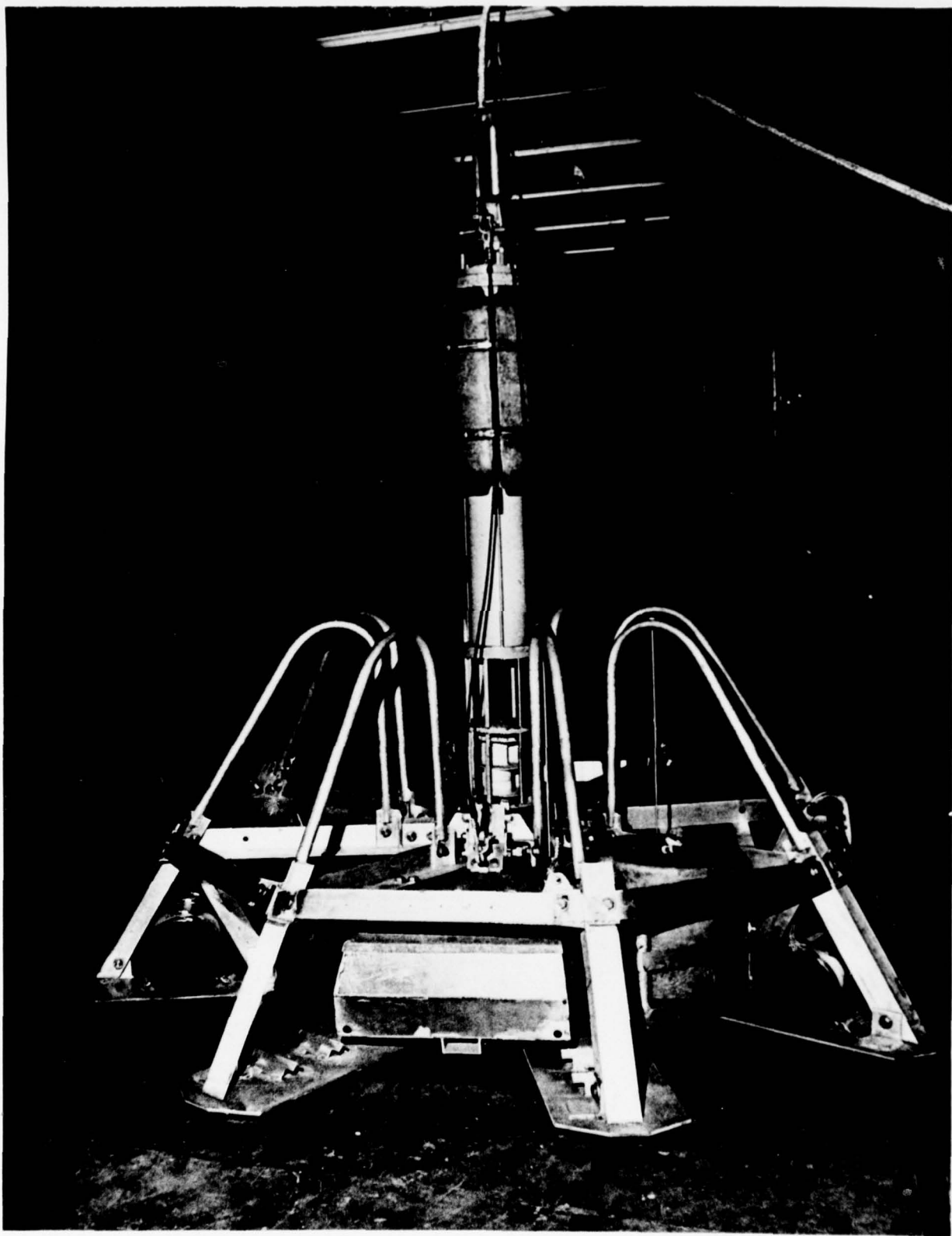
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Fishing Trawl and Net Resistant Bottom Mounted Current Meter

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### ABSTRACT


The accurate measurement of estuary, coastal, and ocean currents are considered essential for the planning of industrial and domestic waste disposal sites, navigation charts, silting and flooding characteristics, and the design of coastal docking facilities. Currents directly affect the navigation of a wide variety of vessels, change the orientation, size and shape of navigable channels, and effect recreational, fishing, and scientific studies.

The apparatus required for the measurement of these currents can be suspended beneath a moored surface buoy, lowered from a surface vessel and placed on the bottom, or attached to a pier or other substructure. Regardless of the method selected, each has deficiencies inherent to its particular design and installation.

A current measuring device mounted beneath a surface buoy can have induced meter motions that degrade the data, as well as drawing attention to the area, which in turn invites pilferage of the equipment. Current measuring devices that are lowered to the bottom usually require the use of a diver to assure proper orientation, and, if a surface buoy is used to mark the location of the instruments, it is again susceptible to possible theft.

In the event the meter assembly is positioned on the bottom by a surface vessel and the lowering line released from the instrument, it requires the use of a diver or grapnel hook assembly for recovery. When using a grapnel as a means of attachment, there is a strong possibility of instrument damage or even loss if the bottom location is not precisely known by the surface personnel. If an acoustic release is used to recall the instrument package, the mooring frame work or anchoring system remains on the bottom and is lost.

The use of an unmarked bottom current measuring device, in addition to having recovery difficulties, is an unknown and unobserved target for nets and trawl lines being dragged across the bottom by commercial fishing vessels. As a result, the current measuring device may be severely damaged or never recovered if it becomes entangled in the fishing net.

In view of these difficulties,  the design of a unique bottom mounted current meter mounting frame was initiated. The device provides some protection from nets and/or cables trailing behind a surface vessel fishing or dragging in the area. On deployment, and before release, it has the capability of relaying its vertical orientation to the surface operator. Through the use of a line messenger, the assembly

can be mechanically released from the deployment line. It does not require an electrical power or instrumentation lead to relay vertical positioning or to accuate the release mechanism. On acoustic recall from a surface vessel, the assembly releases a float and lift line, providing a means of recovering the current meter and the mounting frame.



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## 1.0 DISCUSSION OF THE PROBLEM AND GENERAL APPROACH

This research effort was performed to design, construct, and demonstrate a structure that would support conventional current meters on the bottom in near coastal waters, be deployed and recovered without the use of divers, and provide an anchoring system that would minimize the loss rate and damage resulting from encounters with commercial fishing gear.

The report will cover in detail, all preliminary design concepts, the proto-type design, construction details, weight, handling and current drag characteristics, deployment and recovery methods, and will include a discussion on design improvements based on experience obtained during sea trials.

## 2.0 PRIMARY DESIGN OBJECTIVES

The following design objectives were considered as the primary goals to be met by the operational proto-type. The device must be capable of diverless deployment in coastal water depths ranging between 10 to 65 meters. On implantation on the bottom, a means must be provided to signal the surface that the structure is resting in a position within  $\pm 5^\circ$  of vertical. In the event the device is not vertical, due to obstructions or a sloping bottom, the deployment line should provide surface personnel with the capability of moving the device to an area providing a more acceptable terrain. On final positioning, the deployment line and vertical position indicator must be capable of being mechanically recalled for deployment of additional current meter assemblies.

An acoustic recall device will be attached to the assembly, and on surface command release a float and recovery line stored within the current meter mounting structure. The device should be capable of mounting either AMF-VACM and/or EG&G Model A101-1 current meters, and have the mechanical capability of allowing science personnel to pre-select on the surface, current recordings at either 30 inches or 72 inches off the bottom.

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The mounting structure will have sufficient lifting pads, rings, and/or a handling bridle to facilitate deployment and recovery. The complete structure should be capable of being handled from a vessel in the 40 foot range, and as such, the target weight will be assumed to be approximately 1000 pounds. The final design weight however, will depend on the calculated ballast required to resist the turn over or tip up forces that can be expected from a net ground cable, as well as the added effect of current flow in the 3 to 4 knot velocity range. Ballast material will be ballast of opportunity, either sand, rocks, cement or scrap iron.

### 3.0 PRELIMINARY DESIGN REVIEW

Figures 1 thru 19 illustrate a wide variety of proposed methods, including several workable system concepts suggested by the Office of Naval Research personnel. All concepts have been included in order to provide the user with other unique approaches for possible use with advance design current meters presently being developed. The sketches and their associated captions are self explanatory and a detail description of their operational characteristics will not be given in this report.

#### 4.0 PROTO-TYPE DESIGN CONCEPT

After a careful review of the design goals and the proposed methods illustrated in the previous section of this report, a decision was made to use a knock-down, self recovery concept using deflector bars as a means of allowing cables and nets to ride up and over the current meter assembly. Figure 20 illustrates the basic design of the prototype.

On net contact, the ground cable rides up the sloping sides of the deflector bars, contacting the side wall of the current meter. As side wall pressure increases, the meter assembly over comes the righting moment provided by the hinged counter weight. As ground cable pressure continues, the meter falls over and nests between the openings of the deflector bars. The flexible cable attached between the counter weight and the conical adapter plate at the base of the current meter, acts as a multi-directional hinge, allowing motion in any direction.

The floatation collar is a tight fitting foam with a faired fiberglass housing that will allow the ground cable and net to slide over the device. After passage of the cable and net, the righting moment provided by the counter weight

and floatation collar allow the meter assembly to return to the vertical position. The conical nest serves a dual purpose. (1) it acts as a strong resistance against the drag forces of current flow, eliminating the "Tilt-over" characteristics that would be found in a free swivel or universal joint mounting, using only floatation as the righting force. (2) the conical configuration acts as a snap action switch. It provides a slight resistance to the initial contact of an externally applied force, allowing the meter to move freely if the force continues, as it would in the case of a ground cable or net dragging across the structure. On passage of the dragging object, the combined righting forces of the counter weight and floatation collar begin to reset the meter. As it reaches an angle approximately  $30^{\circ}$  from vertical, the meter snaps back into the conical socket, assuring vertical alignment with relation to the basic frame resting on the bottom.

## 5.0 DESIGN CALCULATIONS

The initial design calculations consisted of, (1) determine the force exerted by a 5 knot current on the side of a rigidly mounted vertical current meter of the VACM and/or EG&G Model A1010-1 configuration, (2) determine the size of a concrete slab or base that would resist the tipping action of a vertical meter in a 5 knot current. The calculations are a preliminary cut at the design size and weight of a base structure. The actual base footing however, will depend largely on the trade-off between physical size and mechanical lay out of individual components such as the AMF 314 release, surface recovery float, float line canister, ballast weight configuration as well as the structural material.

The design review included the possible use of a free floating tethered current meter, including the floatation necessary to maintain the assembly in a vertical position in a 5 knot current.

### 5.1 Drag Force on a Cylindrical Current Meter

A cylindrical current meter with a diameter of 8.5 inches and 50 inches long was used in the calculations. Figure 21 A illustrates the basic configuration. Figure 21 B

is a graphic plot of the drag forces that can be expected at various current flows acting on a rigidly mounted vertical current meter.

#### 5.2 Forces Required to Tip a Rigidly Mounted Current Meter Attached to a Concrete Base

In the assumed configuration, the meter is mounted on a 5 inch thick concrete base 36 inches in diameter as illustrated in Figure 22 B. The weight of the concrete slab is 412 pounds. The current required to tip the base is approximately 9 knots; considerably greater than the working current of 4 knots required by the work statement.

Figure 22 A, illustrates the current forces acting on a free floating tethered current meter. In this case a syntactic foam floatation collar having 40 pounds of buoyancy is attached to the top of the current meter. It acts as the vertical restoring force for the assembly. Calculations show that currents as low as 2.5 knots will provide sufficient drag to incline the tethered assembly greater than 5 degrees. The use of a larger buoyancy collar will reduce the angle slightly, but calculations indicate that by doubling the floatation the drag forces are increased approximately the same amount.

### 5.3 Forces Acting on a Tethered Current Meter With an Offset Buoyancy Block

In an attempt to refine the buoyancy block principle of vertical restoring force, calculations were performed using the offset fin configuration illustrated in Figure 23 A. The calculations plotted on curve 23 B illustrate that the physical size of the offset buoyancy block fin becomes excessive. The buoyancy material used in the calculations was Emerson and Cuming Ecco Float EG-23, which has 41/lbs/cu. ft. density, with operating depths of 915 meters.

Based on the data obtained, it is evident that in addition to the floatation collar, some type of spring restoring force will be required to resist the effect of a 4 knot current.

### 5.4 Current Meter With Pivot Base, Lever and Counter Weight Restoring Action

Calculations were performed on the pivot lever and counter weight assembly illustrated in Figure 24. In the configuration shown, the "Start to Tilt" force is calculated to be 24 pounds. This figure converts to an approximate current flow of 1.5 to 2 knots, considerably lower than the target current flow of 4.0 knots. The 1.5 to 2.0 knot calculated figure was substantiated in shallow water

thru the use of a spring scale attached to the bail at the top of the meter housing. The "Start to Tilt" reaction occurred at 14 pounds, which is comparable to the calculated value.

There are three possible ways to increase the tilt resistance of the meter assembly, (1) increase the ballast weight, (2) move the lever arm pivot point closer to the meter attachment cable, (3) increase the diameter of the flat area on the conical base.

Reviewing the proposed methods to increase the resistance to current drag, and their overall effect on the assembly, the following evaluations are discussed. (1) increasing the mass of the counter weight would increase the air weight of the assembly, substantially adding to ship board handling problems. (2) moving the lever arm pivot point closer to the meter attachment cable requires an increase in the movement of the counter weight to provide sufficient tilt down motion of the current meter. Frame and meter interference would require a larger base structure. (3) increasing the diameter of the flat surface of the conical attachment pad at the base of the current meter appears to be a more logical method of increasing the tilt down resistance. The increased flat plate surface would not re-

quire a larger overall frame diameter, would not increase the height of the frame, and would not appreciably increase the total weight of the assembly.

## 6.0 PROTO-TYPE DESIGN OF TILT OVER ASSEMBLY

### 6.1 Basic Structure:

The basic structure of the current meter mounting frame consists of aluminum pipe, angle, and flat stock. Aluminum alloy was chosen for the proto-type as a result of its availability and ease of fabrication. It is not however, considered satisfactory for long term exposure to sea water conditions. Long term bottom recordings with the device would dictate the use of a more stable material, probably in the stainless steel family. Figure 25 illustrates the top view of the structure showing its symmetrical configuration. The center spider and socket assembly is the common component to which the eight radiating arms and deflector bars are attached. Figure 26 illustrates a typical deflector bar and foot pad assembly. All eight deflector assemblies are identical, and may be interchanged during assembly of the structure. To simplify build-up, all nuts, bolts, flat and lock washers used throughout the frame are identical in size. While the size and strength of the nut and bolt assemblies may be considered as over-kill in some areas, it is felt assembly would be easier if all fastenings were identical.

The frame is 8 ft. 6 inches across the widest

point of the base. It stands 18 inches off the bottom, not including the height of the deflector bars or vertical current meter assembly. The overall height of the assembly, from the bottom of the foot pads to the top of the installed current meter is 8 feet. These dimensions, as well as component weights are detailed on Figure 20. The overall height of the recovery lift bridle, from the base of the foot pads to the lift ring is 9 feet 6 inches.

#### 6.2 Ballast Weight:

Individual ballast weights have been distributed around the base of the structure. Figure 27 illustrates a typical ballast weight assembly. A total of six weights can be accommodated, for a total air weight of 198 pounds. Each container is 8 1/2 inches in diameter, 12 inches long, with the ends closed by Model #1139 plastic capplugs. Stainless steel band clamps are used to retain the capplugs after filling with sand. The weights are easily filled, handled, installed or removed, and may be used to balance the trim of the structure by moving them around the base. Figure 28 illustrates the simplicity of the mounting saddles. Stainless steel band clamps identical to those used to retain the cap plugs, fasten the ballast canisters to the saddle mounts. To assure pressure equalization within the canisters, four

1/4 inch diameter holes have been drilled in the top side wall of each container. The holes provide an entry point for water during descent, and are small enough to prevent sand wash-out during deployment on the bottom. The use of sand as a ballast of opportunity reduces the ballast weight requirements during shipping.

### 6.3 Current Meter Tilt-Down and Recovery Mechanism

Figure 20 represents the simplified version of the lever counter weight assembly use to provide the tilt-down and recovery mode of the current meter.

Figure 29 depicts the current meter in the knock down mode, and illustrates the male and female conical configuration that results in the snap-back self alignment positioning of the meter on recovery. The 3/16 inch diameter flexible stainless steel cable at the center of the cone, provides a multi-position hinge mechanism. The female section of the cone is constructed of aluminum, with the male section being PVC (polyvinyl chloride). The use of this plastic, which is relatively inert in sea water, reduces the possibility of corrosion between the two mating parts.

The counter weight box is illustrated in Figure 30. It is constructed of welded aluminum sheet stock, is sand filled, and has an air weight of 160 pounds. A fiber-

glass cover, located in the upper right section of the photograph, prevents wash out of the sand during deployment and bottom operation. Four one inch diameter holes have been drilled in the top cover to allow free passage of water during descent. Two smaller holes are drilled in the two lower outboard corners of the aluminum box, and fitted with push-in cap plugs. They are used to drain off excess water after recovery.

An adjustment turn buckle, shown in Figure 31, is used to vary the length of the stainless steel hinge cable running between the counter weight and the conical base of the current meter. By adjusting the turn buckle the counter weight can be positioned to provide full travel of the meter in the tilt down mode, while preventing the counter weight from resting on the bottom.

#### 6.4 Current Meter Attachment

Figure 32 illustrates the step clamps used to secure the current meter to the PVC positioning cone. By removing the "U" bail attachment plate from either end of the current meter, the meter can be attached to the plate in a position that will allow current measurement at either 30 inches or 72 inches off the bottom. A PVC adapter plate fits into a cavity machined into the top face of the cone,

and will accommodate the different diameters of the opposite ends of the current meter. Attachment or removal of the meter assembly can be accomplished in a matter of minutes thru the use of a standard 5/16 inch Allen wrench.

#### 6.5 Surface Recovery Float and Release Mechanism

After deployment and bottom release, there are no surface floats or lines to indicate the presence or position of the bottom current meter assembly. To recall the current meter and mounting structure, an AMF 314 pinger release, attached to the current meter frame, is given acoustic instructions from a surface command unit. The pinger is activated by the command and pings for one minute, providing the surface vessel with a means of obtaining a range and bearing on the bottom assembly. When the release is activated, the pinger pulses at twice the normal rate providing surface personnel with positive confirmation that release has occurred. Figure 33 illustrates the location of the AMF 314 pinger release (A), the float (B), and line storage canister (C).

The pinger release is attached to a stainless steel strap band that partially encircles and holds the surface float captive. Figure 34 illustrates the float mounting frame and locking band. The float is 16 inches in diameter and 14 inches long with a stainless steel rod passing thru

the centerline of the float. A stainless steel eye is attached to each end of the rod for attachment of the recovery line as well as to assist in surface handling. The float is constructed with an outer fiberglass shell, with poured in place 8 pound expansion foam used to fill the inner cavity. The positive buoyancy of the float is approximately 60 pounds. Figure 35 illustrates the details of the float locking band attached to the armed release mechanism of the AMF 314.

On release command, the toggle jaw on the release mechanism snaps open allowing one end of the float locking band to fall free as depicted in Figure 36. The opposite end of the clamp always remains attached to the mounting structure. Note the positioning of the unlatched 314 release lever, it has been positioned in a way that gravitational force alone will always open the locking latch when the release is activated. Referring back to Figure 35, the float retaining band clamp has provisions for increasing the strap tension around the float. This is accomplished by tightening the nut on the threaded rod shown in the lower right section of the photograph. This method of float retention required a very high band clamp tension in order to overcome the 60 pound buoyancy. A simple design modification

was initiated reducing the band clamp tension on the frame, float and release mechanism.

Referring to Figure 37, the band clamp and surface float have been modified to include a single dimple or female hemispherical cavity in the side wall, with a matching male hemispherical protrusion attached to the clamp. A short pin has also been welded to the vertical pipe used at the float storage rack. The pin shown in Figure 35, restricts the upward motion of the retainer band clamp, while the two mating hemispherical sections securely lock the float with a minimum of strap tension.

#### 6.6 Recovery Line Storage Canister

The recovery line canister is located adjacent to the surface float and secured next to and parallel to the AMF release pinger. It is constructed from a PVC (polyvinyl chloride) tube 25 inches long, with a 10 3/4 inch outside diameter. Figure 38 illustrates its mounting location in relation to the other components.

The canister has a storage capacity of 375 feet of 1/2 inch single braid polyester line, having a 7000 pound breaking strength. The line is faked in the container in a random Figure eight until the storage tube is filled. Figure 39 graphically illustrates the recovery line packing method

and the attachment points to the surface float and lift bridle. On completion of the packing procedure, a PVC retainer baffle is pushed down on top of the line, and secured with three stainless steel cotter pins inserted into equally spaced holes drilled in the end of the tube wall. Figure 40 illustrates the baffle inserted in the line storage canister. The baffle construction is such that it provides a smooth running take-off for the line faked within the container. The widest baffle is on the bottom when the container is attached to the frame in it's horizontal mounting position, as shown in Figure 41.

Figure 42 is a close up of the baffle illustrating its construction details. Through the use of none kink single braid polyester line, Random Figure Eight faking, and the play-out ability of the PVC retainer baffle, there has never been a faulty line deployment. Each float release played out the line from the canister smoothly and without hackles at test depths ranging between 30 and 100 feet.

The recovery line passes from the retainer baffle thru a rectangular tubular fair lead attaching directly to the base of the recovery float as illustrated in Figure 43. On release, the float and line raises between the two net deflector bars shown in Figure 44. To preclude

the possibility of the float tilting at an angle during the release mode, and wedging between a set of deflector bars, two vertical guide rods have been installed as indicated by the arrows in the photograph. The opposite end of the recovery line is attached to the three part bridle that is faked between the net deflector bars, and is secured to the current meter base with either Marlin or light weight nylon tie wraps. The recovery or lift of the bottom weight of the assembly is sufficient to break these fastenings, deploying the three part lift bridle to its recovery position.

#### 6.7 Vertical Indicating Acoustic Pinger and Transducer System

##### 6.7.1 Vertical Indicating Acoustic Pinger:

The vertical indicating acoustic pinger illustrated in Figure 45, mounts on the mechanical messenger release bracket, and is used to inform the surface vessel of the bottom current meter's deviation from a vertical position when placed on the bottom. It is a self contained unit mounted in a stainless steel container 3 1/2 inches in diameter and 8 inches long. The pressure resistant case has been designed for a working depth of 300 feet.

In use, an external magnetic on-off switch is

actuated on the device prior to lowering the current meter and frame into the water. The device transmits a 50 Khz acoustic signal. When the current meter and frame is resting on the bottom, and is vertical within a 5 degree circular pattern around an imaginary vertical line, the ping rate is once per second. If the current meter is tilted greater than the 5 degree circular pattern, the ping rate increases to a pulse rate of twice per second. The self contained mercury battery system provides a total on-time life of 90 days. The device was designed and manufactured by Smith and Root Inc. Vancouver, Washington.

#### 6.7.2 45 Khz Monitor Receiver Assembly

The receiver is of conventional design consisting of a low-noise preamplifier, tuned gain stages, a local oscillator, mixer and an audio amplifier. The pre-amplifier uses a low noise Crystallonics type CM 641 field effect transistor with a gain of approximately 40 DB. The preamplifier will provide sufficiently low noise reception for signals down to ambient noise levels, provided the hydrophone cable is kept short, (i.e. less than 10 to 15 feet). Figure 46 illustrates the receiver system.

The tuned amplifier stages bring received signals up to a sufficient level to allow heterodyne action.

A CMOS type 4047 free running oscillator provides the heterodyne signal. Mixing is accomplished in the switching mixer, providing both sum and difference frequencies. The lower (difference) frequency is passed by the 741 audio amplifier while the sum frequency is rejected. The power output is sufficient to drive a set of Pickering Model OA-2 headphones. Figure 47 illustrates the receiver schematic.

### 6.7.3 Transducer Pick-up Assembly

The receiver transducer assembly illustrated in Figure 48 is a commercial item manufactured by Lindon Laboratories Inc., State College, Pennsylvania. The following information is the manufacturer's published specification data for the assembly:

Frequency:	50Khz $\pm 5\%$
Sensitivity:	
Transmit (db re 1 microbar/volt/meter)	64
Receive (db re 1 volt/microbar)	-72
Beam Width (-3 db)	30°
Band Width (-6 db)	7Khz
Impedance (OHMS typical)	300 - J280
Capacitance	7000 Pfd. Typ.
Pulse Power	500 Watts
Weight	3 1/4 Lbs. With Cable
Cable	30' long, 2 conductor shielded, 2 AWG, PVC Jacket

The transducer is a reasonably rugged assembly, being constructed with an outer case of heavy gauge Lexan. A styrene Butadiene rubber disk is located in the base of the Lexan shell, providing the Piezo ceramic crystal with an efficient acoustic window. The transducer as shown, is attached to a 6 foot length of PVC pipe in order to provide a means of lowering the device over the side of the surface vessel.

#### 6.8 Mechanical Messenger Release Mechanism

##### 6.8.1 Operation And Construction Of Release

The requirement for a non-electrical release dictated the use of a mechanical trip mechanism that was reliably activated by a weighted surface to bottom messenger. Figure 49 illustrates the trip mechanism latched to the top of a typical "U" bolt bail found on most current meter end caps. The design of trip mechanism provides the operator with three important operational characteristics, (1) through the use of three adjustable threaded foot pads, a wide range of "U" bolt bail sizes and lengths are readily accommodated, (2) the threaded foot pad arrangement provides the operator with the means of adjusting the pinger assembly to a vertical position relative to the current meter housing, (3) it provides a release mechanism that is not dependent on the use of electrical power leads.

Figure 50 illustrates a cross sectional drawing of the trip mechanism. It is constructed of type 316 stainless steel, and consists of a mouse trap release mechanism that is tripped by the upper spring loader lever illustrated in the photograph on the right. The notch in the lower bail latch lever is off center from the pivot point, assuring a clean drop-out when the device is triggered.

In use the mechanical trip is latched to the current meter bail, and the foot pad adjustment rods extended until the release is pre-loaded sufficiently to prevent side play. After loading, and to prevent inadvertent release, a cotter pin may be inserted thru a safety lock hole in the side plate of the device. Figure 51 illustrates the trip release, safety lock pin, and the vertical indicating pinger secured to tabs welded on the release side plate. The cable shackled to the ear at the lower left of the photograph is attached to the over-center toggle assembly at the counter weight box.

Figure 52 illustrates the surface messenger at instant of contact with the trip lever, almost instantaneously, the trip device is released and the pinger, surface messenger, and mechanical release pull away from the

current meter as depicted in Figure 53.

#### 6.8.2 Mechanical Release Trip Messenger

Figures 54 and 55 illustrate the line messenger used to trigger the release mechanism on the current meter. The basic device consists of two slotted brass tubes. The over all length is  $7 \frac{3}{8}$  inches, the maximum diameter at the bell mouth end is  $3 \frac{5}{8}$  inches. The air weight of the device is  $7 \frac{1}{4}$  pounds. In use the outer tube is rotated until the slots line up as illustrated in Figure 54. This allows the messenger to be attached to the surface deployment line at any point along its length. The outer shell is then rotated 90 degrees, locking the messenger on the line as shown in Figure 55.

The deployment line is held taut and the messenger released. Its rate of descent is approximately 6 feet per second depending on both the tautness and angle of the deployment line. The line messenger has decoupled the mechanical release at deployment line angles as great as 20 degrees in 40 foot water depths. As a point of interest, in one test the messenger failed to trigger the release in a water depth of 90 feet with the deployment line angle at an estimated 35 degrees. A one inch shackle was

hooked around the line and dropped triggering the release at the bottom current meter. While the mechanical release and messenger cannot be considered as a fool proof deployment method, it is a rugged, uncomplicated device that is easily assembled and unless a hackle develops in the deployment line, or the line angle becomes excessive, it will perform satisfactorily. Figure 56 illustrates an exploded view of the device, illustrating its construction simplicity.

#### 6.8.3 Over-Center Toggle Release

The over-center toggle release mechanism is an essential requirement for deployment of the bottom current meter assembly. Referring to Figure 20, the profile view of the meter structure illustrates the main components of the tilt-down mechanism. In its basic form, the meter base is attached to the counter weight lever arm thru the use of a flexible stainless steel cable, and is held into the meter base cavity through the down force exerted by the sand filled counter weight.

During deployment, the meter and its mounting structure are lifted by the line attached to the release mechanism secured at the top of the current meter. As the meter is lifted, the counter weight rises and the current meter cone uncouples from its mating cavity. The frame is

now free to rotate about the cable, resulting in possible cable unravel and frame instability in rough weather conditions.

To prevent this, a toggle release mechanism, Figure 57, locks the counter weight in the down position, holding the two cone sections in mating contact during all lift and lower operations. A tag line is attached to a welded ear on the messenger release as illustrated in Figure 58. When the release is triggered, a slight pull on the lowering line will un-couple the toggle allowing the counter weight to operate in its normal manner. The sketch in Figure 59 illustrates the construction details, while Figure 60 depicts the relative location of the various components when the toggle is attached to the counter weight structure.

#### 6.8.4 Current Meter Floatation Collar

The floatation collar mounted at the top of current meter, is used to assist the counter weight in restoring the meter housing to a vertical position after a knock-down has occurred. It has a total positive buoyancy of 52 pounds, and provides the initial righting force until the meter reaches a position approximately 30 degrees from vertical. At this time, the combined forces of the counter weight and floatation collar, snap the meter into a vertical

position, firmly engaging the two mating cones at the base of the meter.

Figure 61 illustrates the construction of the floatation collar. It consists of three separate segments, constructed with an outer fiberglass shell. Each segment has been filled with pour in place expansion foam having a 10 pound per cubic foot density. The three sections are secured to the current meter housing through the use of stainless steel band clamps.

## 7.0 DEPLOYMENT, RECOVERY AND BOTTOM TEST OF THE CURRENT METER ASSEMBLY

### 7.1 Meter Tilt-Down Resistance To Steady State Current Flow:

The initial test of the bottom current meter assembly was undertaken in 15 feet of water. The assembly was deployed on a level bottom, in essentially a zero current location. A line and spring scale were attached to the top bail on the meter housing, and a steady pull exerted on the line. The pull was slowly increased until the mating cones became unseated. Calculations using the lever arm length and spring scale reading at the instant of breakaway, substantiate the meter was capable of remaining vertical in a 2 knot current.

The tilt-down resistance can be varied by increasing or decreasing the weight of the counter weight. For a stiff meter resistance the counter weight ballast could be changed to concrete or scrap steel. The present sand ballast air weight of 160 pounds appears satisfactory for a 2 knot design current.

### 7.2 Messenger Release and Acoustic Recall:

The meter assembly was deployed in 90 feet of water, and positioned within the 5 degree vertical requirement. The position was verified through the use of

the vertical indicating pinger and surface receiver. The messenger was released and approximately 13 seconds later the release mechanism was uncoupled from the meter.

An AMF acoustic surface command unit was used to accuate the 314 release. On command, the 314 pulsed for 1 minute verifying it had received the command. When the release was activated, the pulse rate doubled, indicating the float had been released. A short time later the float and recovery line had reached the surface and the assembly recovered. Several additional tests verified the messenger release and float recovery mechanism operated satisfactory.

### 7.3 Bottom Cable Drag Tests:

In preparation for the cable drag tests, the current meter was loaded on the forward deck of the surface support vessel shown in Figure 62. The test site was in 45 feet of water. The surface markers were deployed as illustrated in Figure 63.

Prior to deployment, light weight Marlin was tied between the net deflector bars on the current meter frame. The Marlin line would act as breakaway tell tales in the event the net ground cable made contact with

the meter housing and forced it into the tilt-down mode. Meter deployment, acoustic readout from the vertical indicating pinger, messenger release and uncoupling of the mechanical release mechanism were satisfactory and uneventful. Meter location on the bottom was approximately as depicted by the sketch in Figure 63.

The second vessel was rigged with the trawl net doors, with 75 feet of ground cable tying the two aft ends together. Experience indicated the doors were flying at the bottom with an approximate 50 foot spread between them. Four passes were made through the deployment zone, two in a north to south direction, two in a south to north set. There were no indications of hang-up during the first three sets. On the fourth run, the set snagged and brought the dragging vessel to a halt. At this time it was unknown if the ground cable or one of the doors had snagged on the current meter or the frame.

The dragging vessel put additional strain on the trawl cables and after several minutes, the current meter housing and its floatation collar broke the surface about 40 feet aft of the dragging vessel. On retrieval of the meter and float assembly, it was observed that trawl door ground cable had wedged under and between two sections of the floa-

tation collar, as illustrated in Figure 65. Further investigation revealed the current meter hinge cable at the conical base had been severed as shown in Figure 66.

Recreating the possible failure mode, it would appear that the trawl door ground cable ran up and over the deflector bars, hit the current meter housing causing it to tilt down as shown in Figure 67. As the cable continued to move in the direction of tow, the cable snagged under the floatation collar and remained fast. Continued movement of the dragging vessel most probably resulted in the leading edge of the mounting frame to dig into the bottom sediment, flipping the assembly upside down. The severe strain on the meter hinge cable caused it to fail, and the meter and floatation collar floated to the surface.

The actual position of the frame was unknown at this time. The AMF 314 was given a command to release the recovery float. The 314 unlatched the float and sent an acoustic verification of the release mode. The float did not surface, and it was assumed the mounting frame was either on its side or upside down on the bottom. Divers verified the frame was resting upside down as illustrated in Figure 64.

The float had been released by the AMF 314,

but was held captive by the bottom support brackets. The divers freed the float by pushing it down and out of its cradle. Float and recovery line deployment to the surface was satisfactory. Recovery of the mounting frame was uneventful after the float reached the surface.

Inspection of the mounting frame revealed four of the eight Marlin tell tails had been broken, indicating that the current meter could have operated in the tilt-down mode as a result of ground cable contact. While it is understood that at least some of tell tails could have been broken at the time the structure turned over, cable marks and scrapes on the net deflector bars opposite to the snapped Marlin line, tend to indicate at least two successful encounters and pass-overs had occurred.

The snapped Marlin tell tails and ground cable markings were diametrically opposite, with one pass indicating a north to south encounter, with the second pass being a south to north contact.

## 8.0 PROPOSED IMPROVEMENTS AND MODIFICATIONS OF THE SYSTEM

Based on the test program and operational observations, the following proposed modifications are suggested to improve the system.

### 8.1 Frame

To simplify the construction of the base mounting frame, it would appear that the present eight net deflectors could be reduced to a maximum of four. The reduction would provide additional room for the float, and prevent hang-up if it was released in partially tilted position. The reduced number of deflector bars would also decrease water turbulence in the area of the savonius rotor, and current directional vane. Referring to Figure 26, the present tubular deflector bar should be carried down to the foot pad, eliminating the angle aluminum structure illustrated in the Figure.

### 8.2 Hinge Cable

The existing 3/16 inch diameter 7 x 19 multi-directional hinge cable used to attach the current meter housing to the counter weight assembly, should be replaced with a 5/16 or 3/8 inch flexible stainless steel cable. While the existing cable has sufficient strength, an added safety factor would be beneficial if the meter assembly were flipped over as occurred

during the original dragger test. The attachment points could be modified to use standard cable clips in lieu of the existing threaded swaged end fittings, providing the user with an easy field fix without the use of special attachment tools.

### 8.3 Skirt Deflector Plates

The skirt deflector plates shown in Figure 25, were installed to prevent ground cable rollers or lead depressor balls from hanging up on the frame structure. However, the detrimental effect of disturbing the current flow around the current meter rotor and vane, may rule out this method of protection. It is suggested that the use of vertical tubular bars set to match the base angle may be a more satisfactory arrangement.

### 8.4 Recovery Float and Mounting Frame

In view of the possibility that the mounting frame can be flipped over on its side or upside down, the surface recovery float system should be modified to assure release. It is proposed that the present cylindrical float be changed to a true spherical shape. In a configuration of this type, the spherical float would "Roll" out of the mounting frame even if the structure was resting on its side. And, by modifying the mounting frame to allow roll out from either

end, the float would be released regardless of the structure's position on the bottom.

#### 8.5 Floatation Collar

As seen in Figure 65, the present floatation collar has an inherent weakness of allowing the ground cable to snag on the fiberglass shell. While this failure was not anticipated, it is considered important that the device was recovered with the ground cable still wedged between the segments of the collar. The proposed modification is obvious and would consist of a more streamlined floatation collar, and elimination or reduction of the space between the segments.

#### 8.6 Mating Conical Base Assembly

The tilt-down and snap back recovery action provided by the two mating conical sections at the meter base, were considered as very satisfactory. It is not proposed to modify this action. Fabrication however, could be simplified if the male and female sections were constructed using a vacuum bag fiberglass laminate technique in lieu of the present aluminum and PVC materials. It is also proposed, that the flat surface area of the mating conical base, be increased in diameter in order to provide additional meter tilt resistance as discussed in Section 5.4.

## 9.0 MAJOR FINDINGS AND ACCOMPLISHMENTS

The following findings and accomplishments summarize the results of this research program.

9.1 The fabrication and test of the bottom mounted current meter demonstrated the feasibility of a structure design that has trawl and dragger net resistant characteristics. Based on the design requirements, the device has demonstrated its ability to be deployed and recovered without the use of divers. The mechanical release mechanism and messenger system has successfully shown that the current meter and mounting frame can be deployed and released by surface personnel without depending on an electrically powered release.

9.2 The use of an acoustic vertical indicating pinger and its associated surface receiver provides the user with the ability to set the device on the bottom and be assured that it is resting in a position that is within  $\pm 5$  degrees of vertical.

9.3 The self contained surface float, 375 feet of recovery line, and the AMF 314 release mechanism have demonstrated the assemblies ability to be deployed, remain on the bottom in an unmarked location, then be recalled for recovery at the discretion of surface personnel.

9.4 The device has been designed to use standard size fasteners throughout, eliminating the need for special hardware. Depending on location on the assembly, numerous piece parts or components are like items, or mirror images reducing the assembly time to a minimum.

9.5 Ballast material is considered as ballast of opportunity, and may be sand, rocks, scrap iron, cement or concrete.

9.6 The air weight of the assembled and ballasted device is 1200 pounds, or 200 pounds over the initial target weight suggested in the original proposal. Deployment from a 40 foot conventional hull vessel is possible, but is not considered advisable unless the vessel is a deep displacement or catamaran type hull. Davits or rigging must have the capability of at least a 6 foot over the side reach, and a 10 foot over the rail lift capability, and have a sufficient safety factor to handle the 1200 pound load.

9.7 The counter balance and conical pivot assembly has sufficient resistance to withstand a 2 knot current without allowing the meter assembly to lean or tilt down outside the established 5 degree from vertical setting.

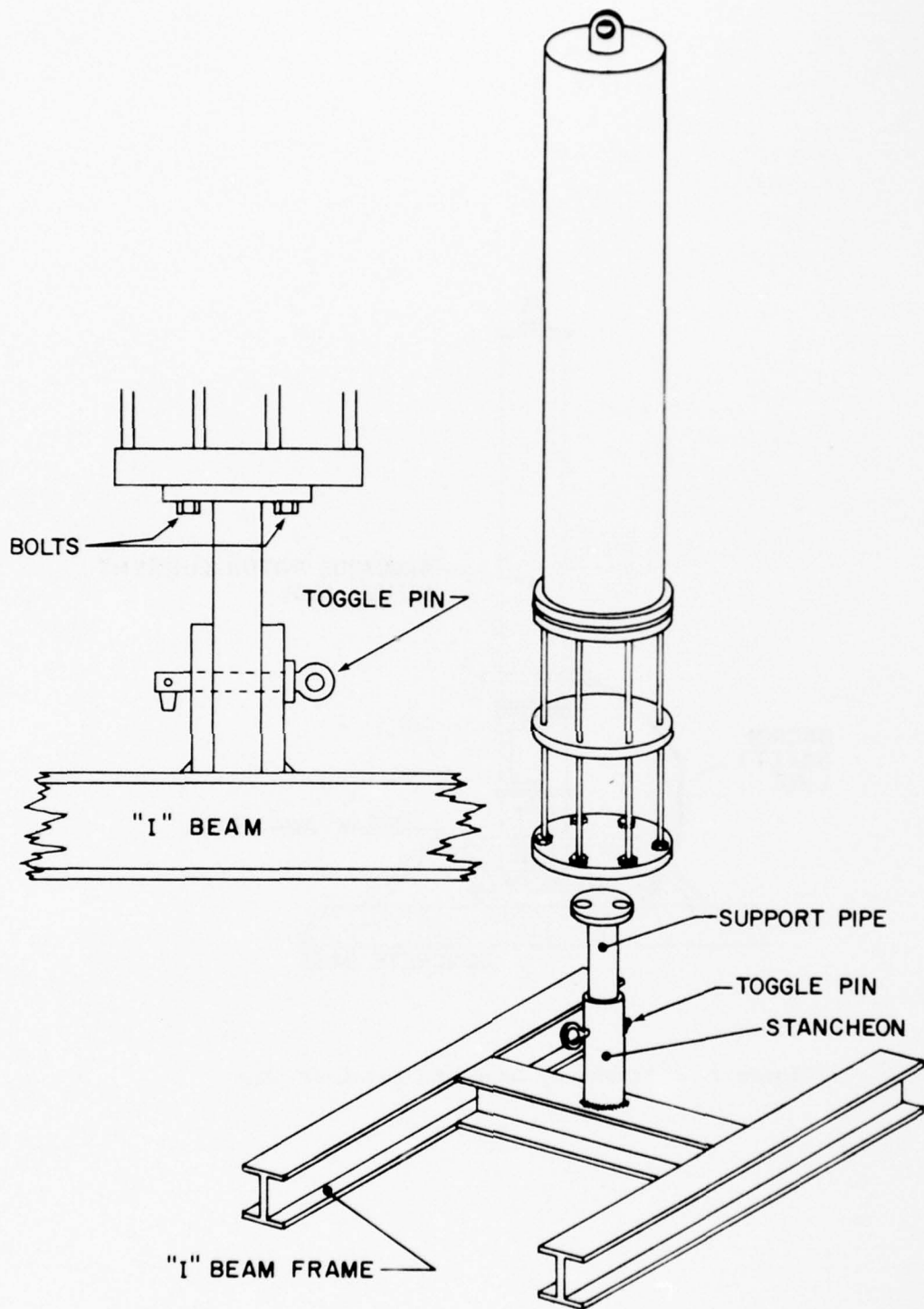


Figure 1 Rigid Pipe Current Meter Support Base

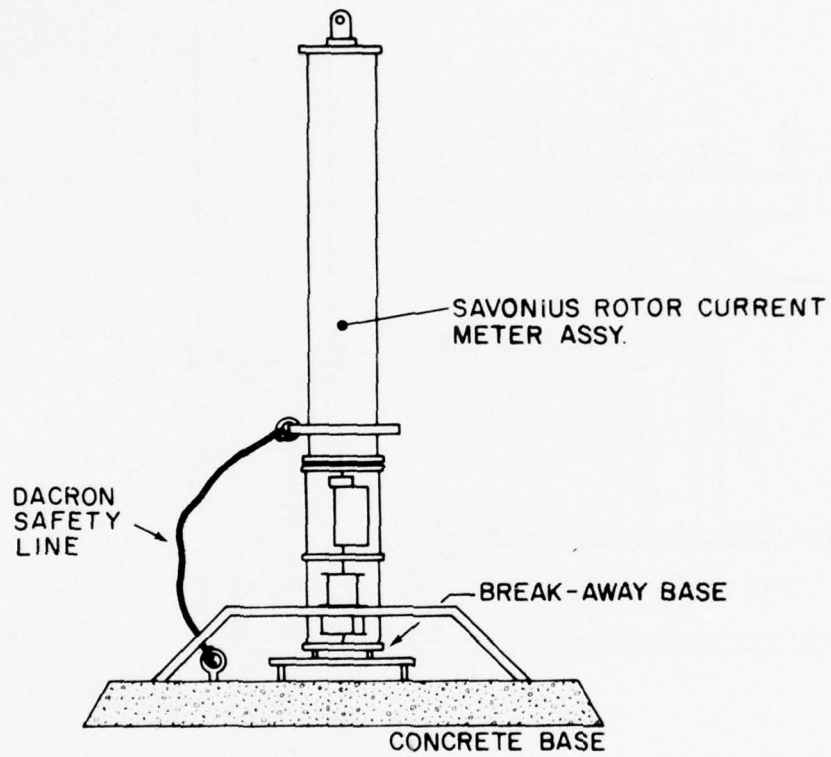


Figure 2 Breakaway Base and Retainer Line

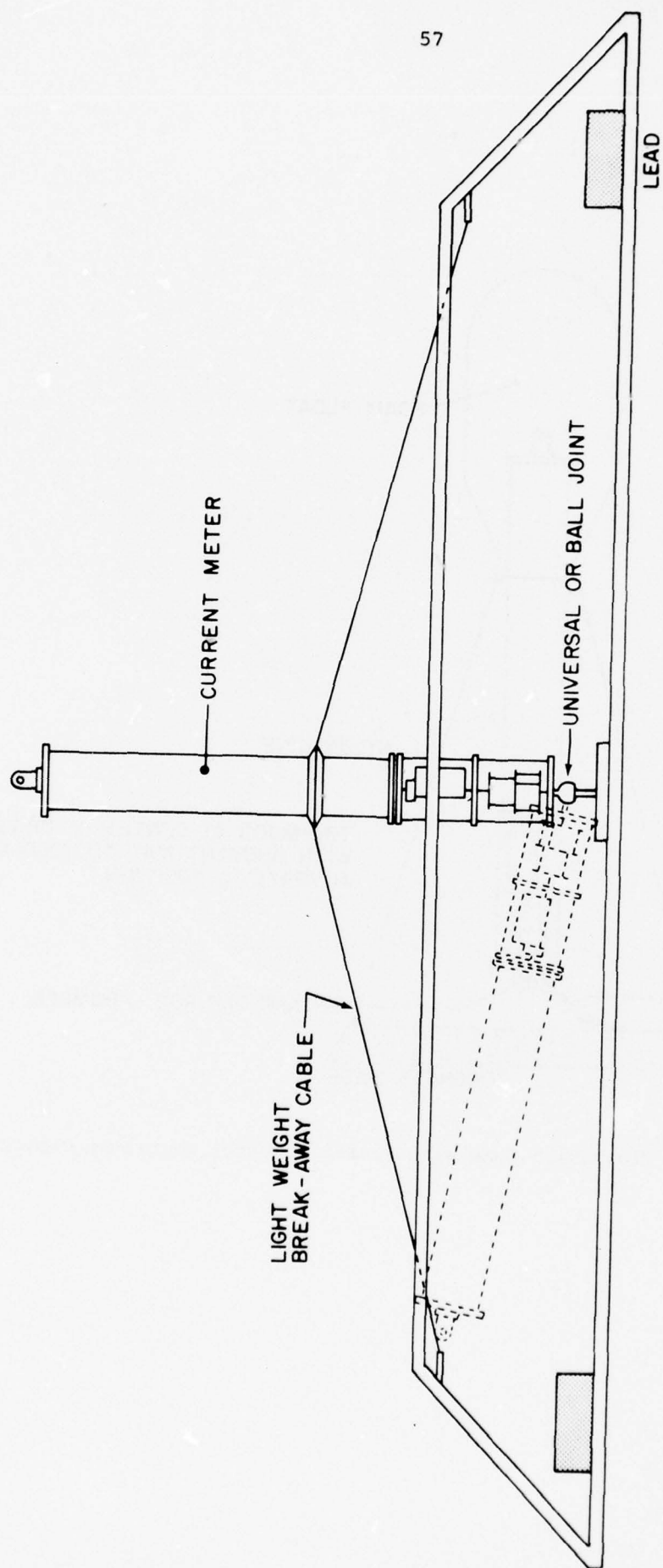


Figure 3 Breakaway Cables and Mounting Base

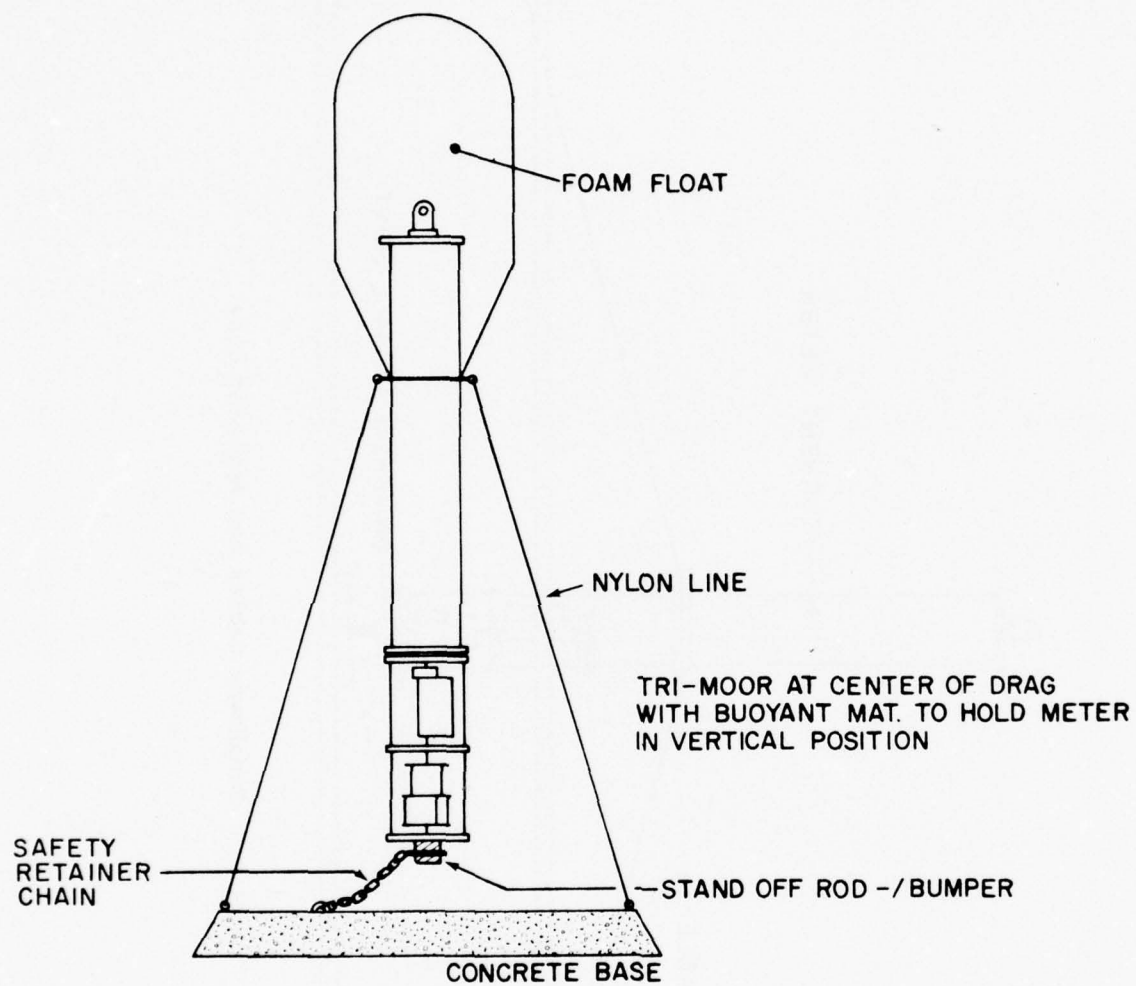


Figure 4 Floatation Dome With Flexible Tether Restraint Cables

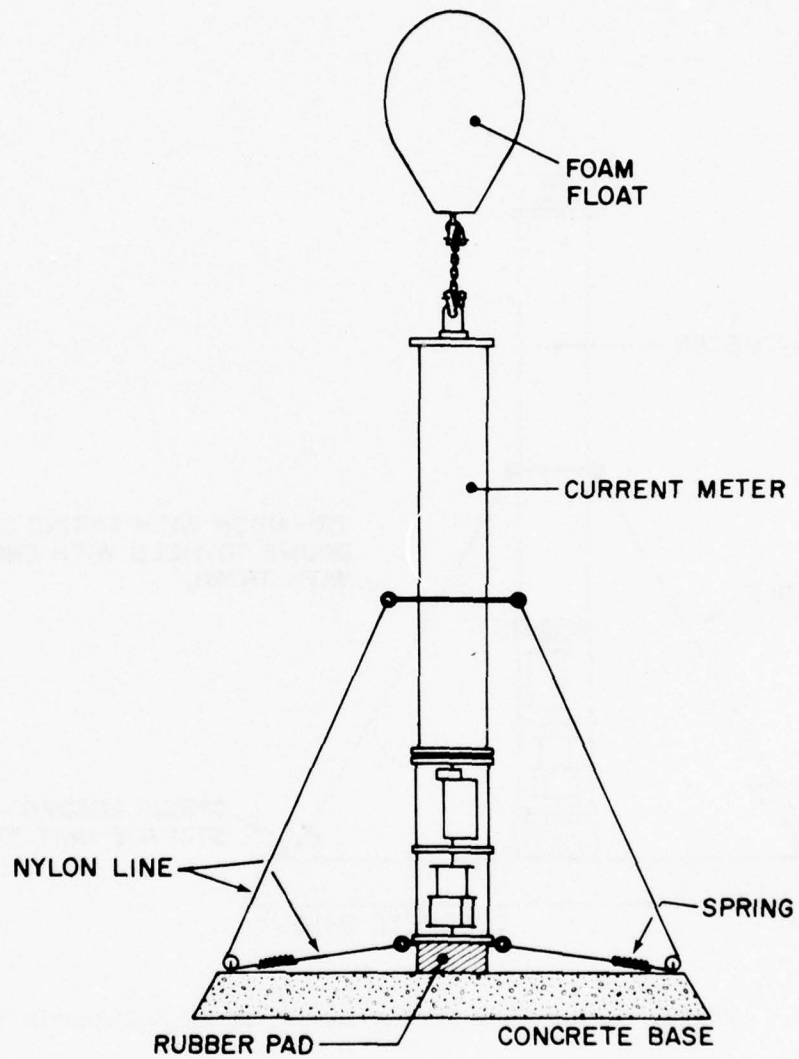


Figure 5      Floatation Ball With Spring Loaded Tether  
                 Cables and Rubber Base Pad

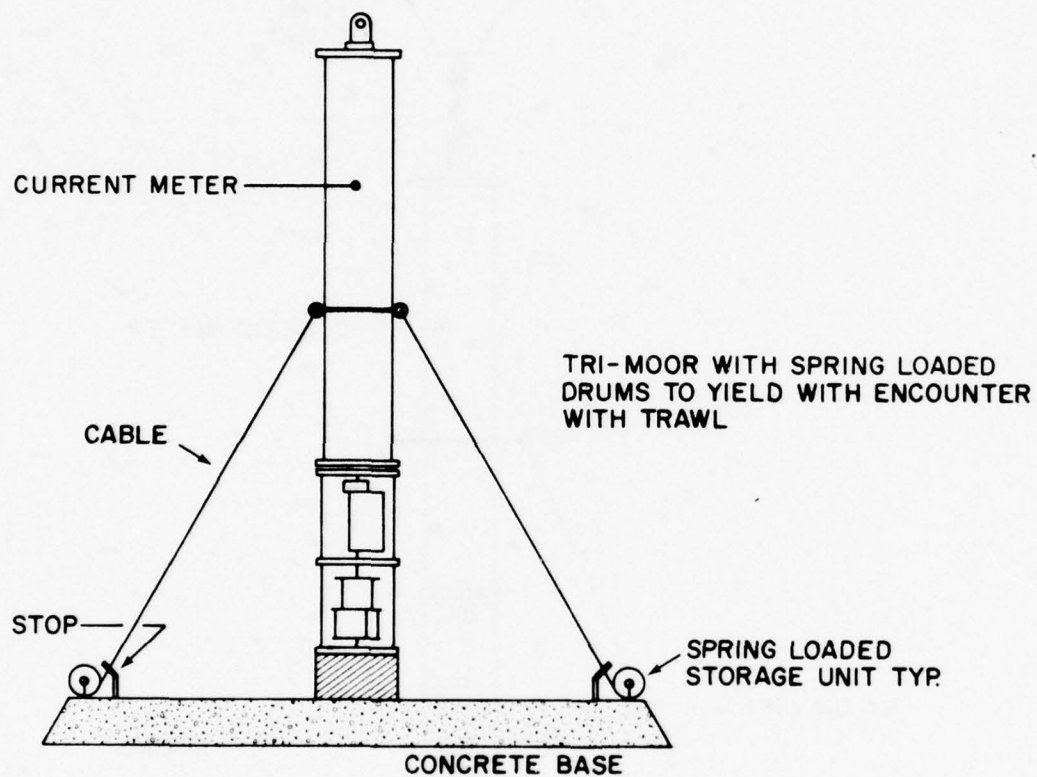


Figure 6 Tether Cables With Spring Loaded Drums and Flexible Mtg. Pad

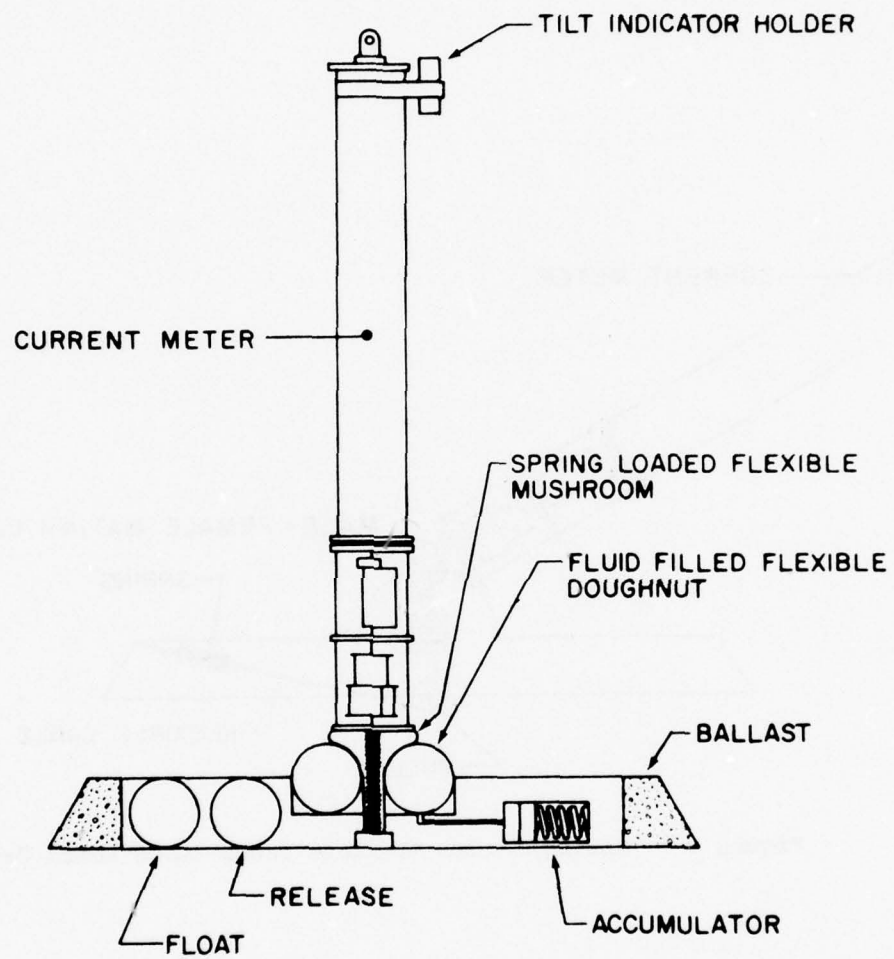


Figure 7 Flexible Rubber Mushroom Mounting Pad

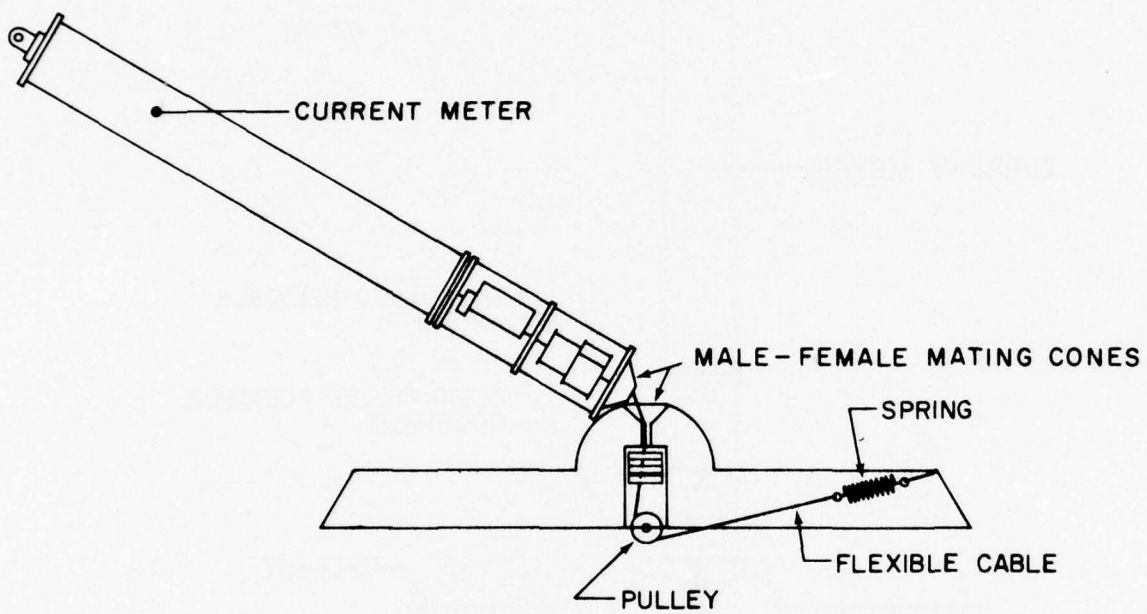


Figure 8 Spring Loaded Flexible Cable (Long Reach Cable)

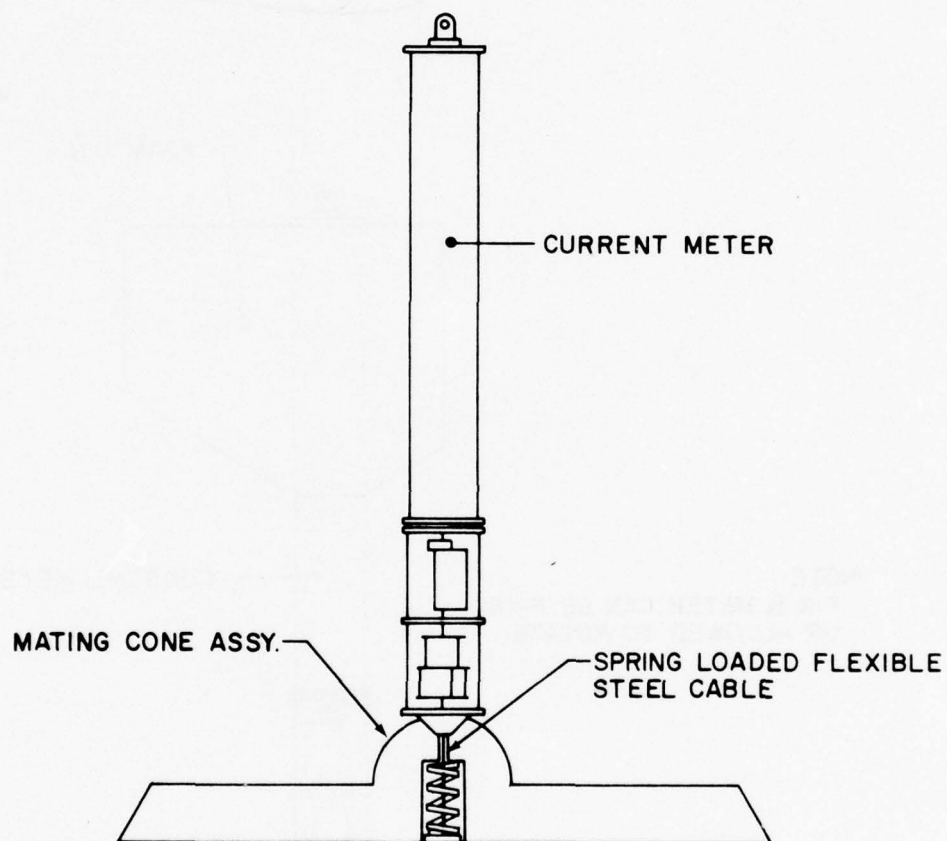


Figure 9 Spring Loaded Flexible Cable (Short Reach Cable)

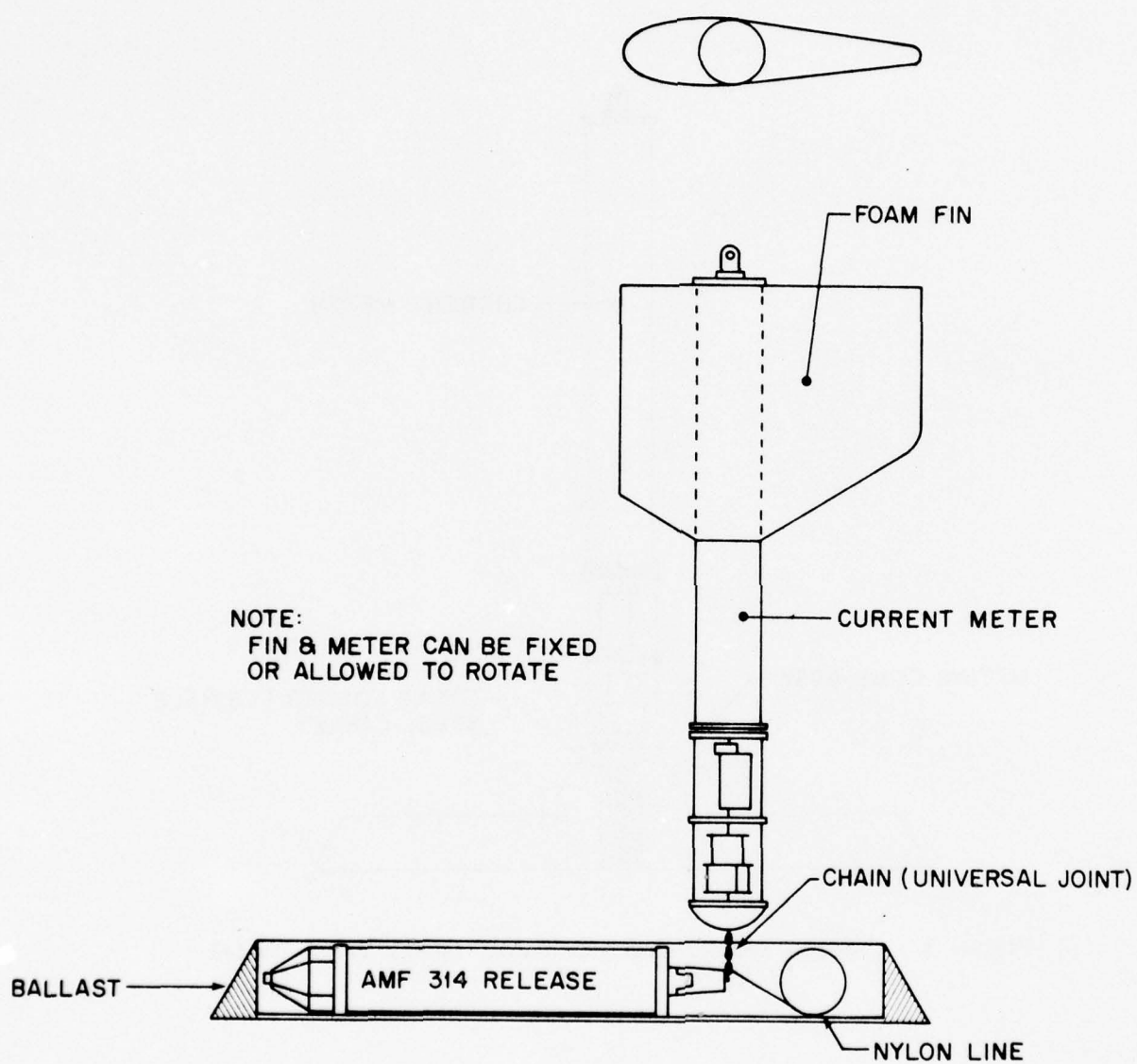


Figure 10 Free Floating, Flexible Chain Link Mounting Base

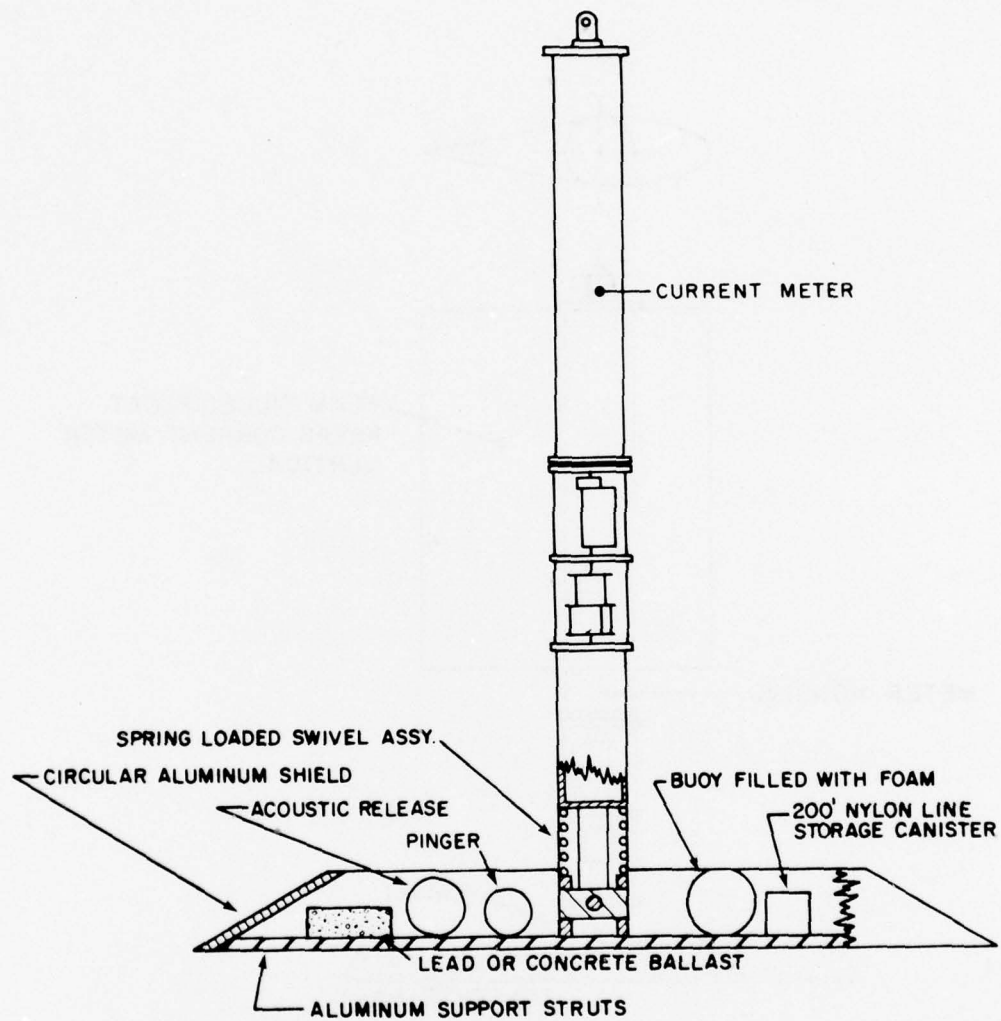


Figure 11 Free Standing Spring Loaded Flexible Mounting Base

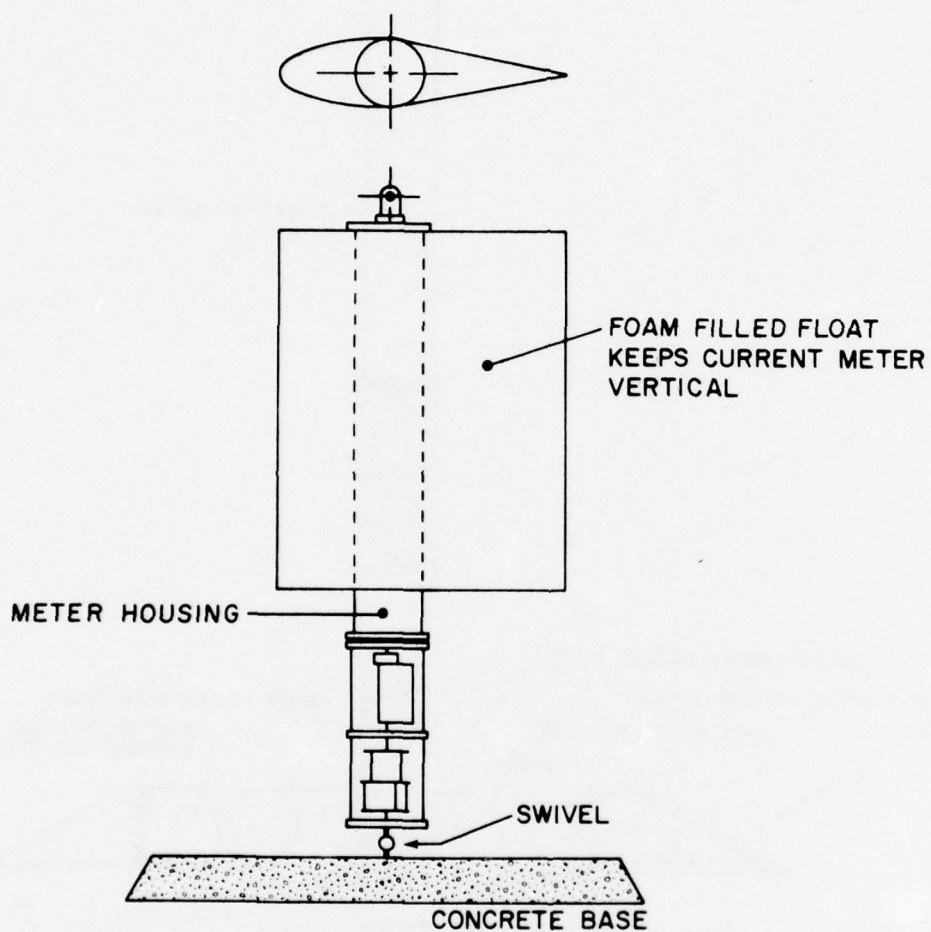


Figure 12 Free Floating Meter With Flexible Swivel Mounting Base

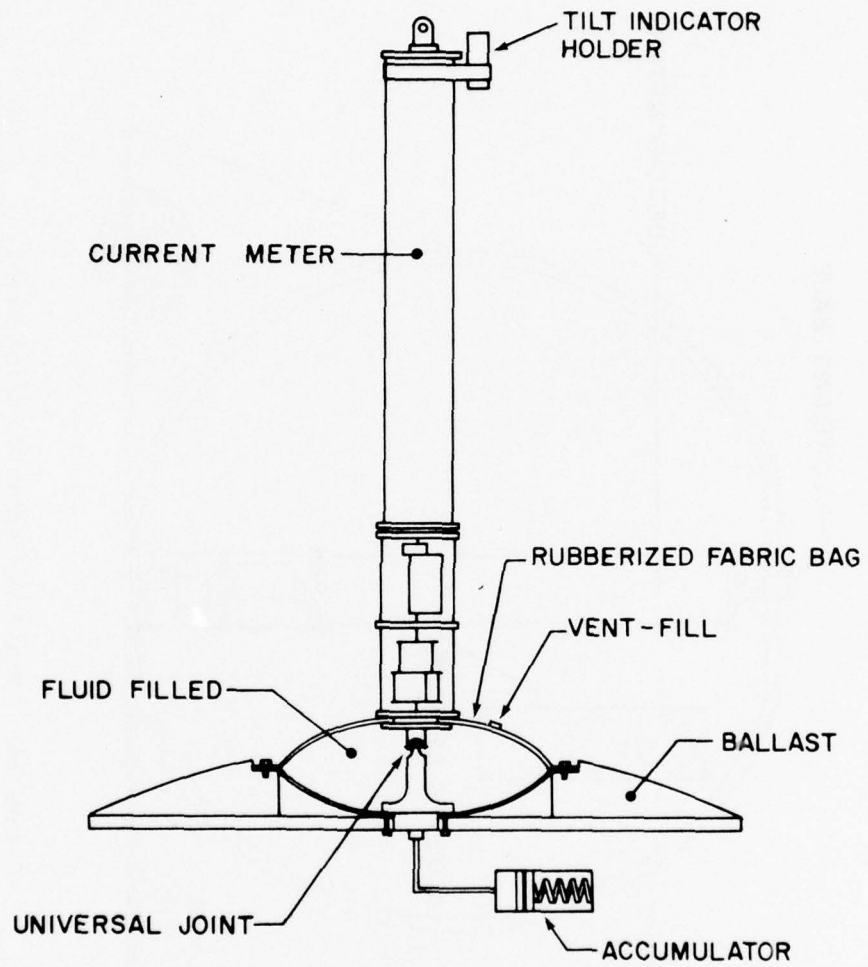


Figure 13 Fluid Filled Semi-Rigid Cushioned Mounting Pad

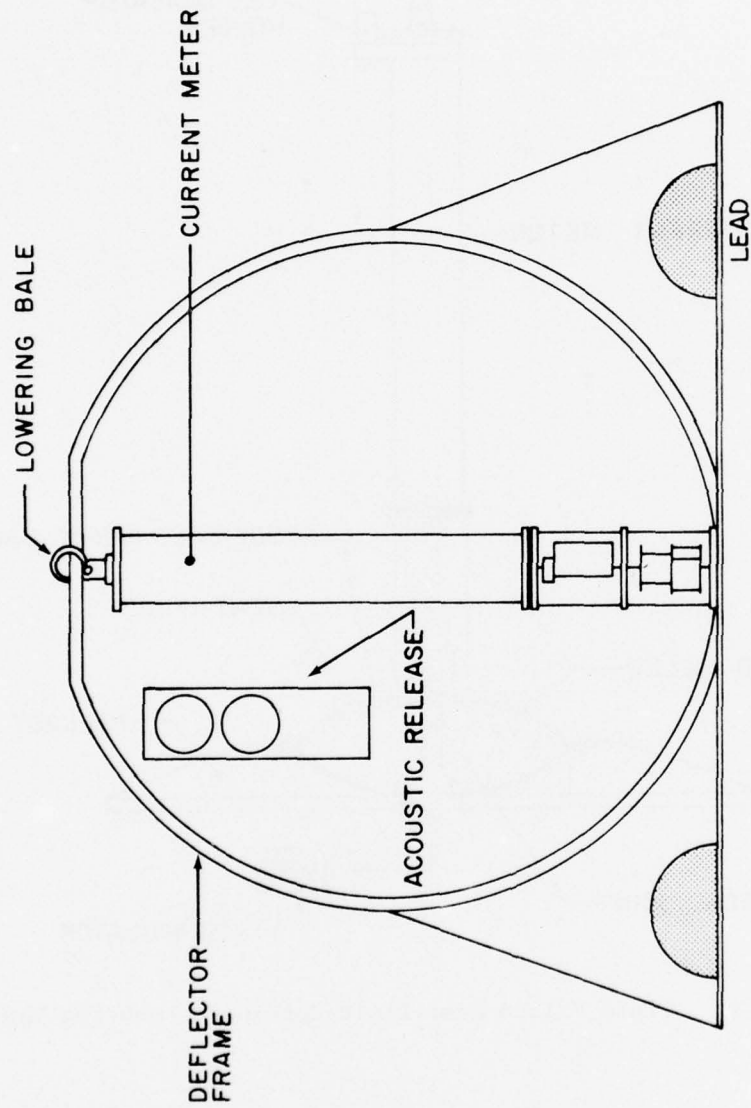


Figure 14 Rigid Deflector Mounting Frame

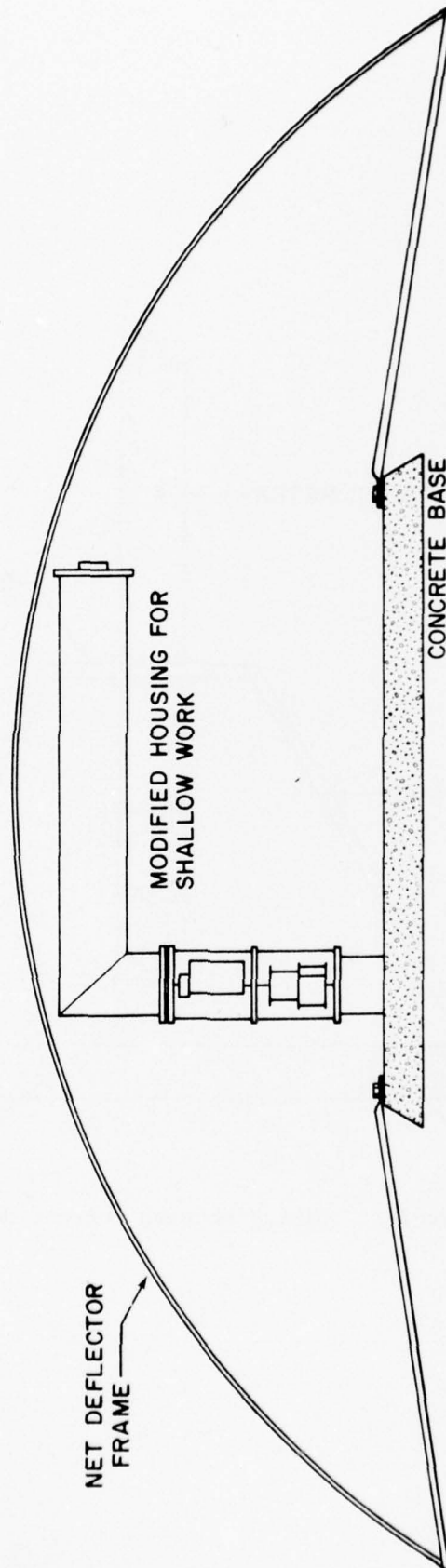


Figure 15 Modified Meter Housing and Rigid Deflector Frame

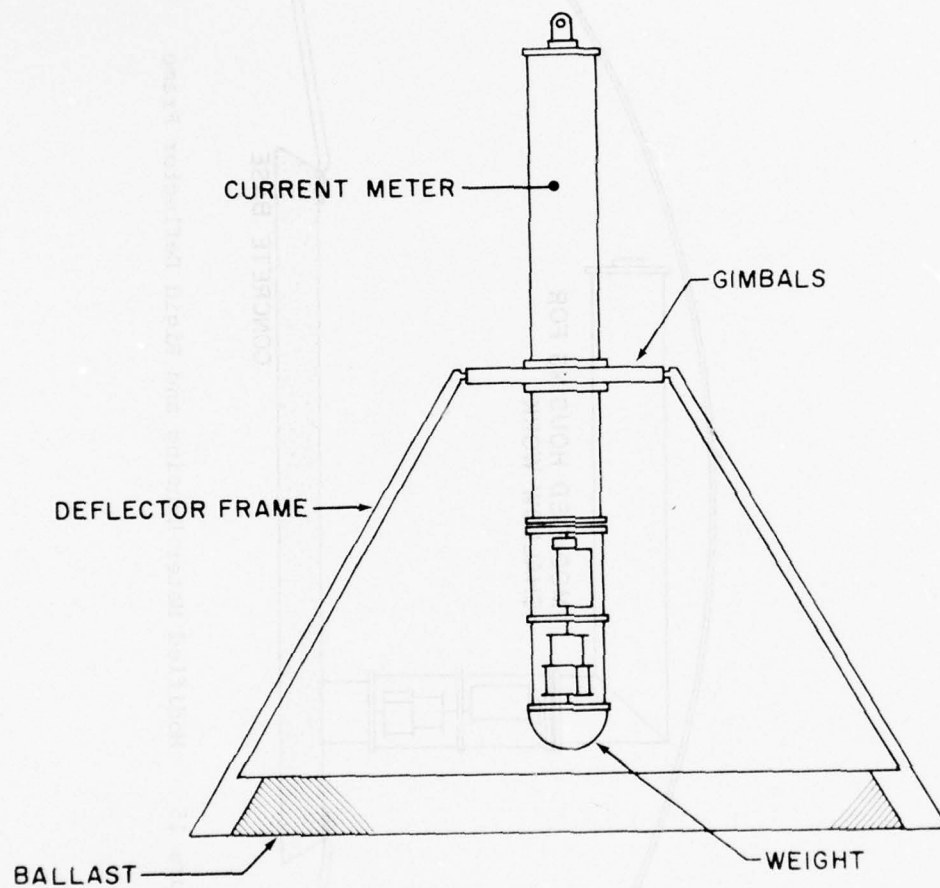


Figure 16 Gimbal Mounted Current Meter Assembly

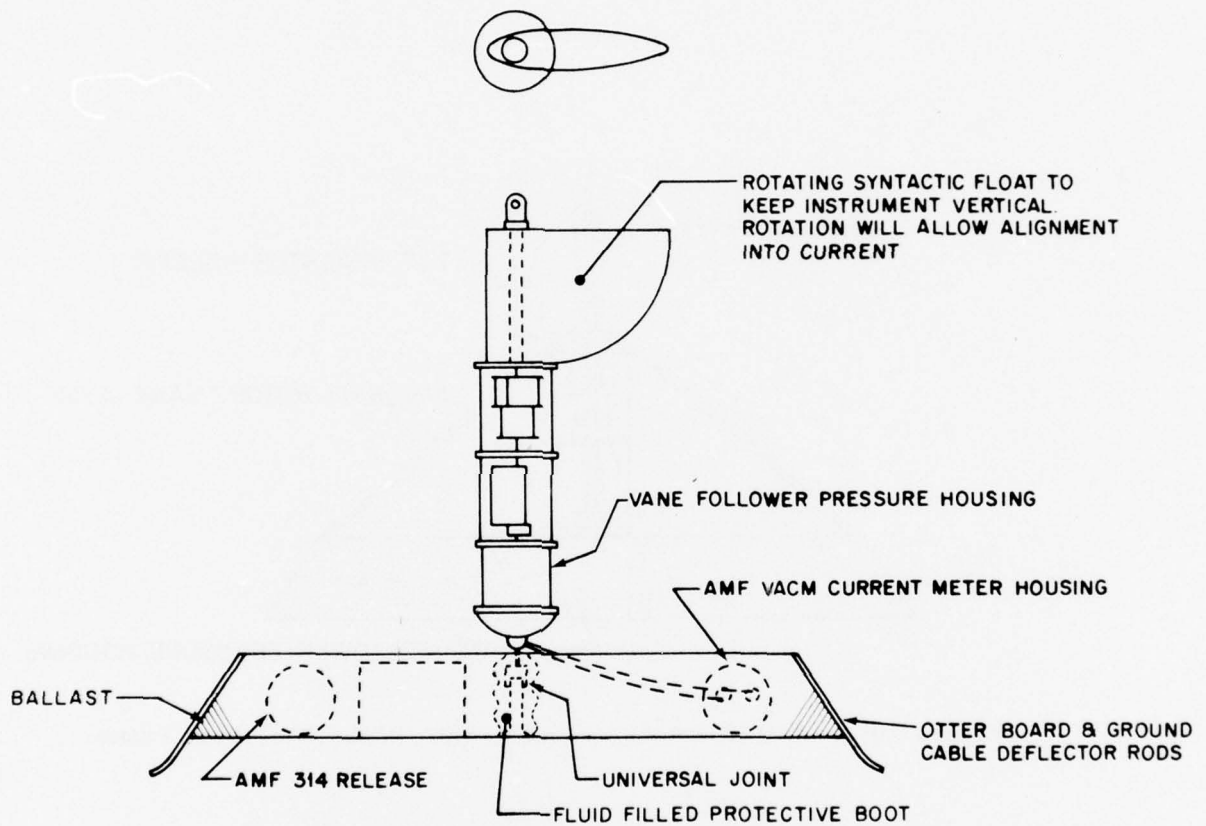


Figure 17 Modified Meter Housing With Swivel Mounting Pad

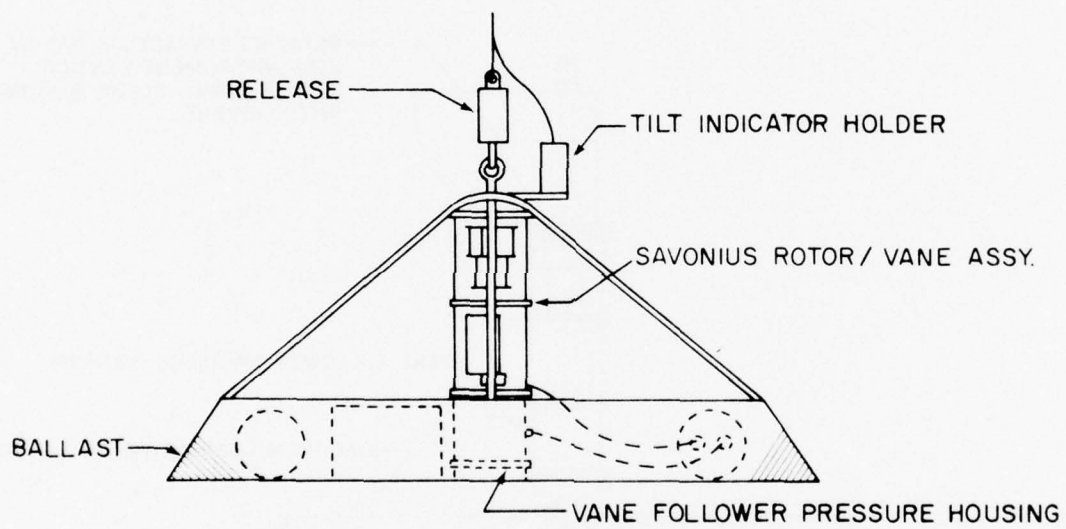


Figure 18      Modified Meter Housing With Rigid Deflector Frame

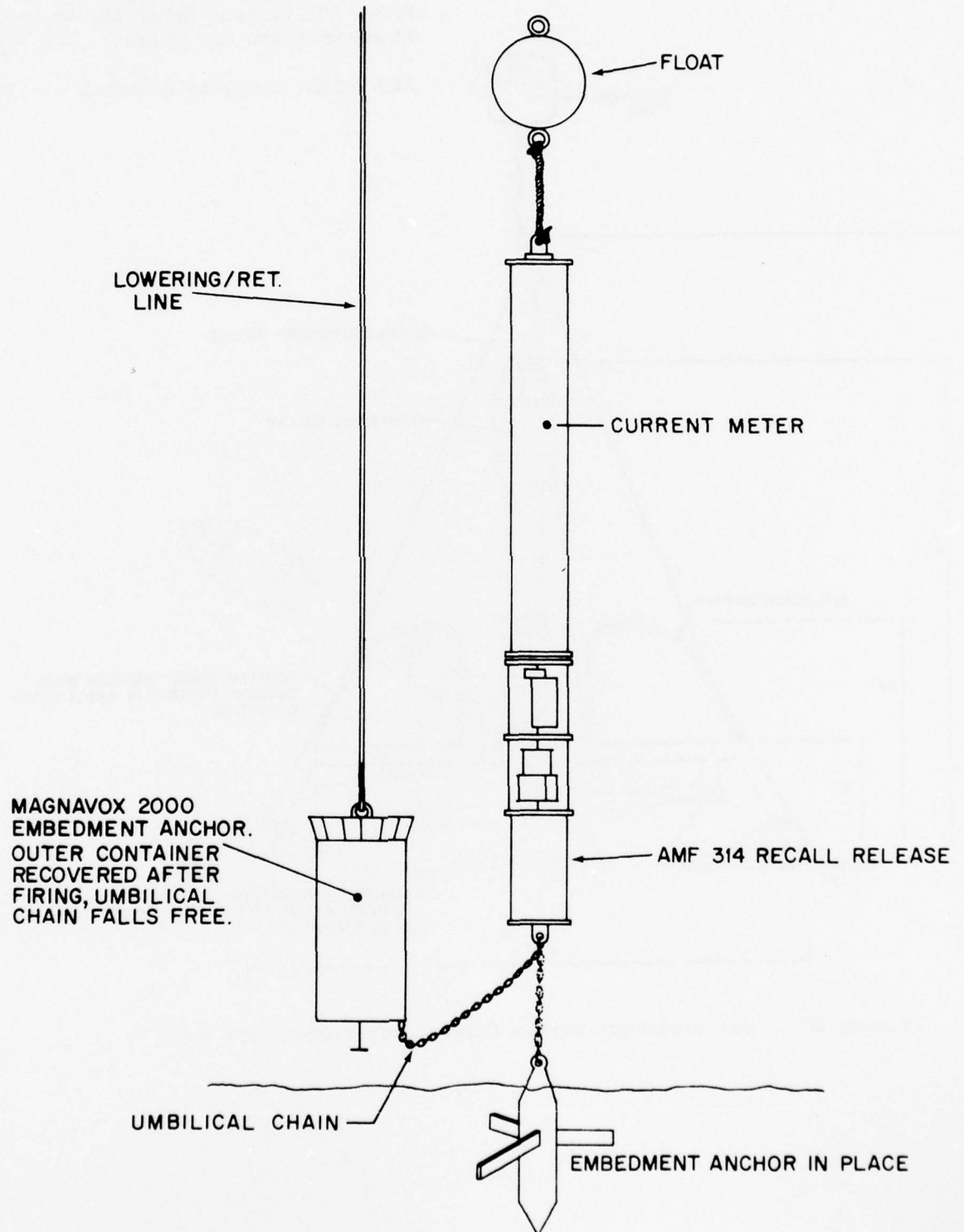


Figure 19 Embedment Anchor With Free Floating Meter Assy.

Total Air Weight 6 Ballast Cans = 198 lbs.  
 Air Weight Counter Weight = 160 lbs.  
 AMF 314 Release Air Weight = 67 lbs.  
 Model 201 Current Meter Air Wt. = 120 lbs.  
 Aluminum Frame Air Weight = 655 lbs.

Air Weight Complete Assembly 1200 lbs.

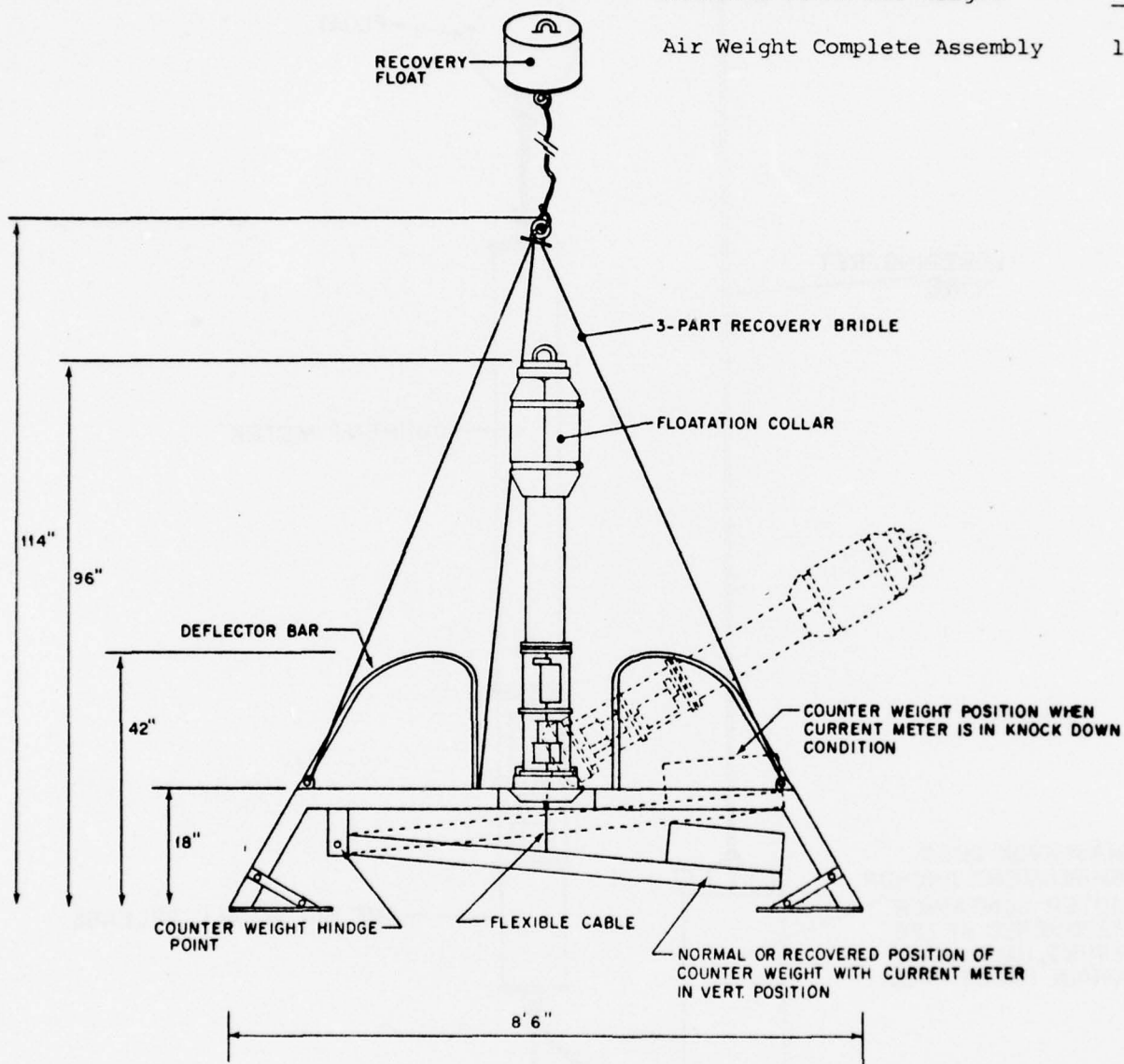


Figure 20 Net Resistant Bottom Current Meter Prototype Assy.

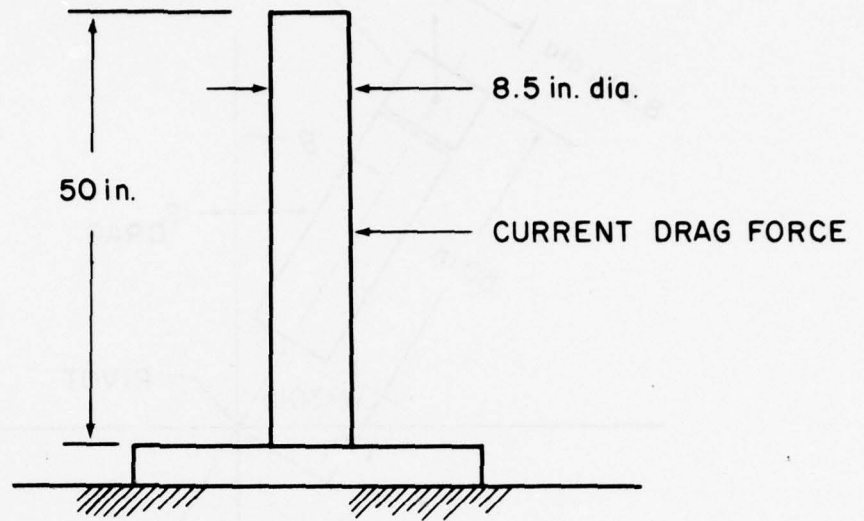


Figure 21A Rigid Mount Vertical Current Meter

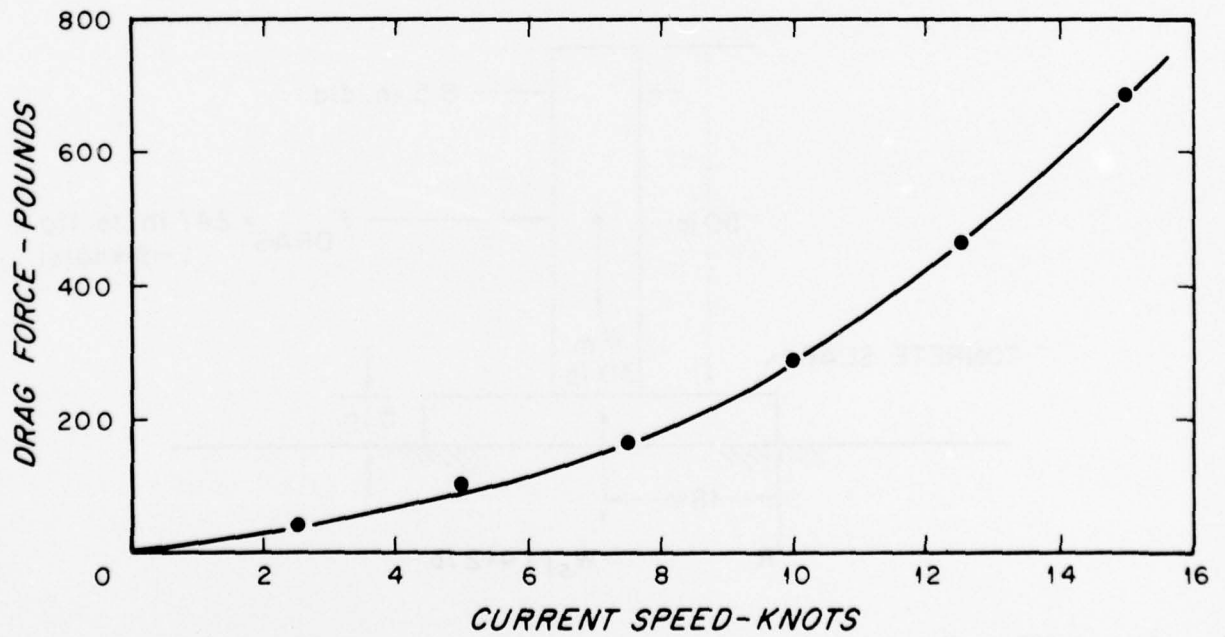


Figure 21B Drag Force on Vertical Current Meter

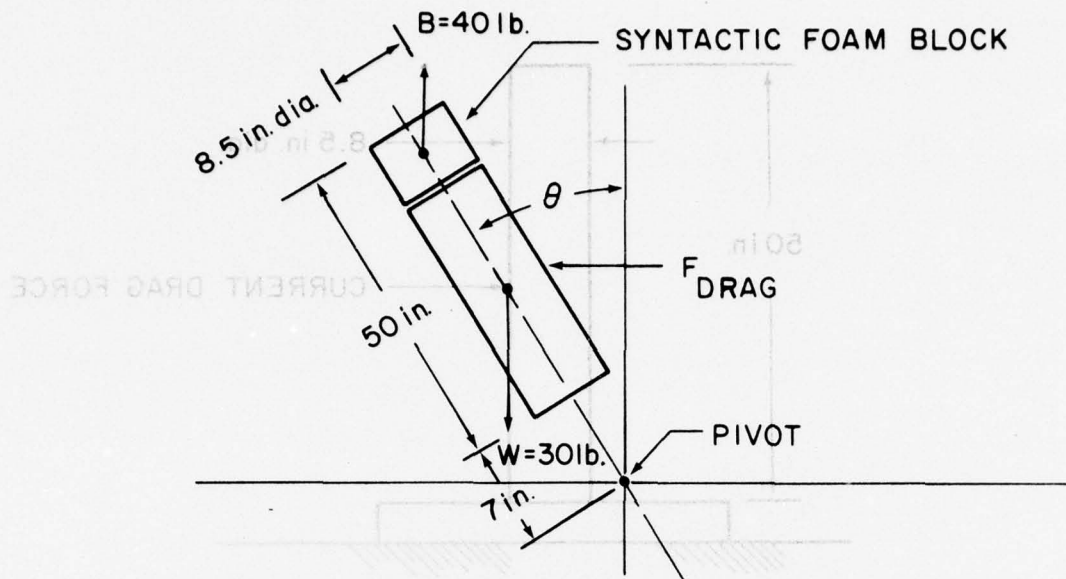


Figure 22A Forces Acting on Free Floating Tethered Current Meter

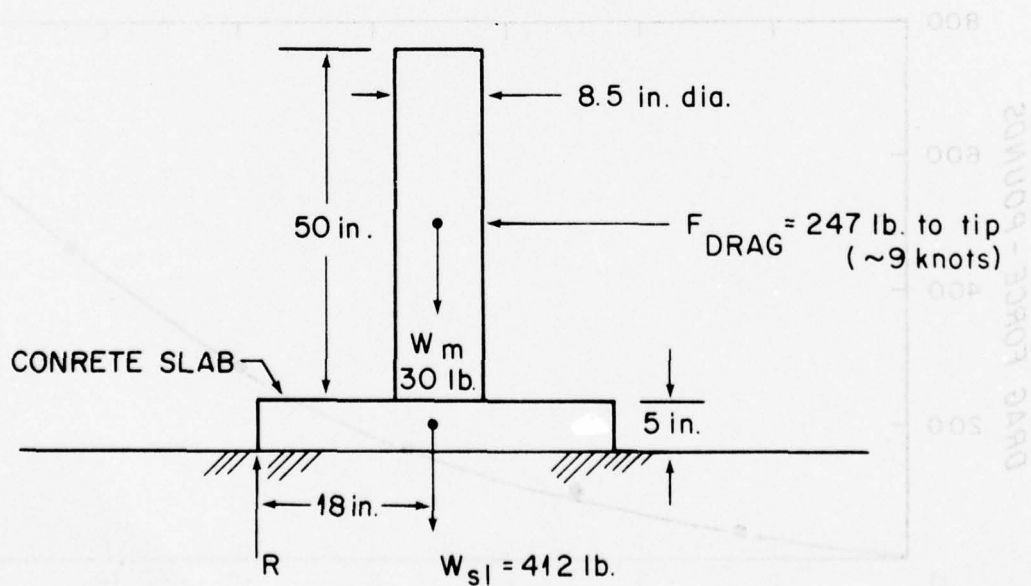


Figure 22B Forces Acting on Current Meter Rigidly Attached to Solid Slab Base

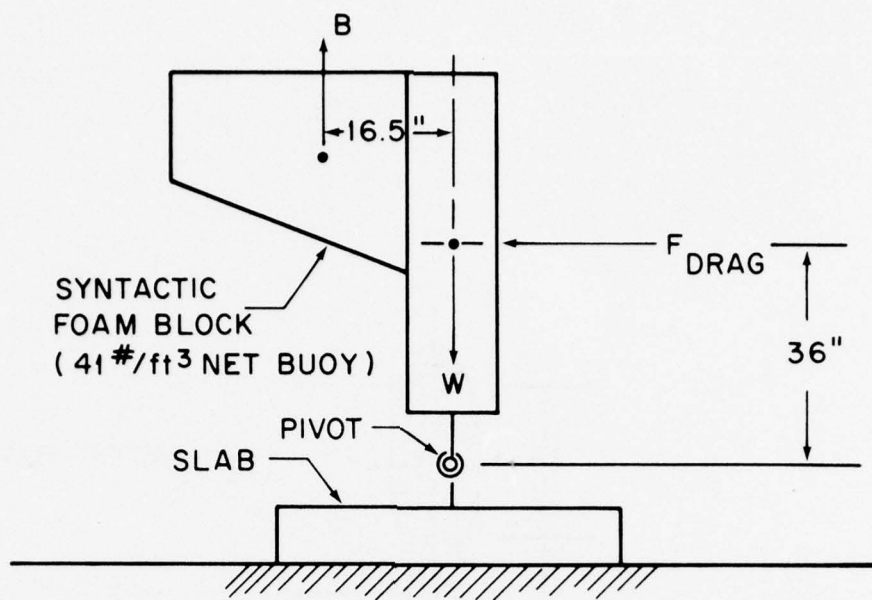


Figure 23A Forces Acting on Tethered Current Meter With Offset Buoyancy Block

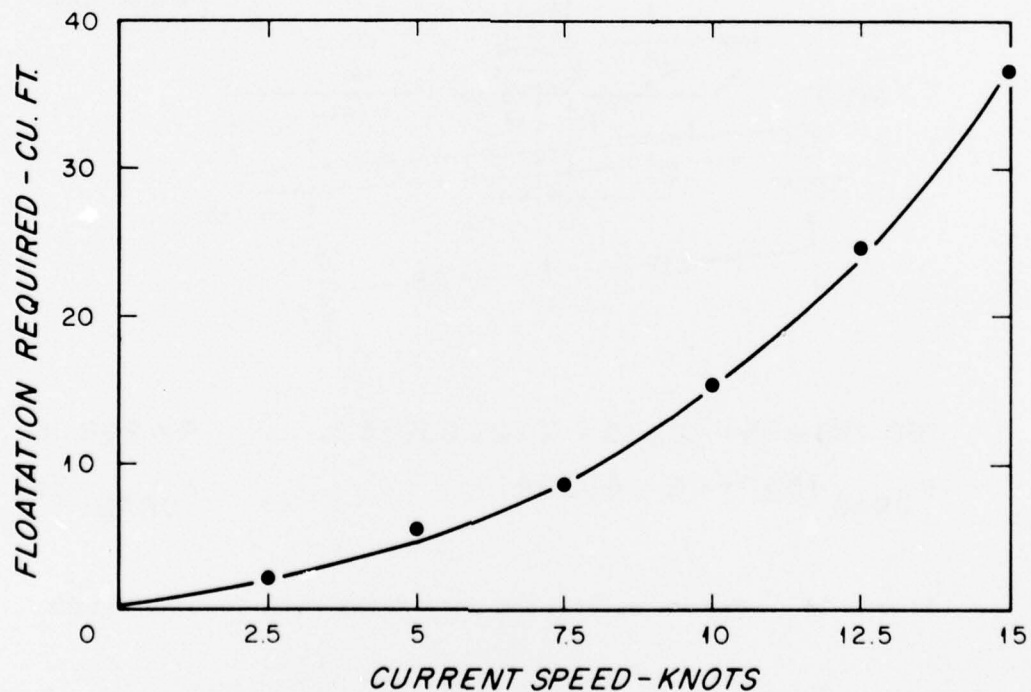
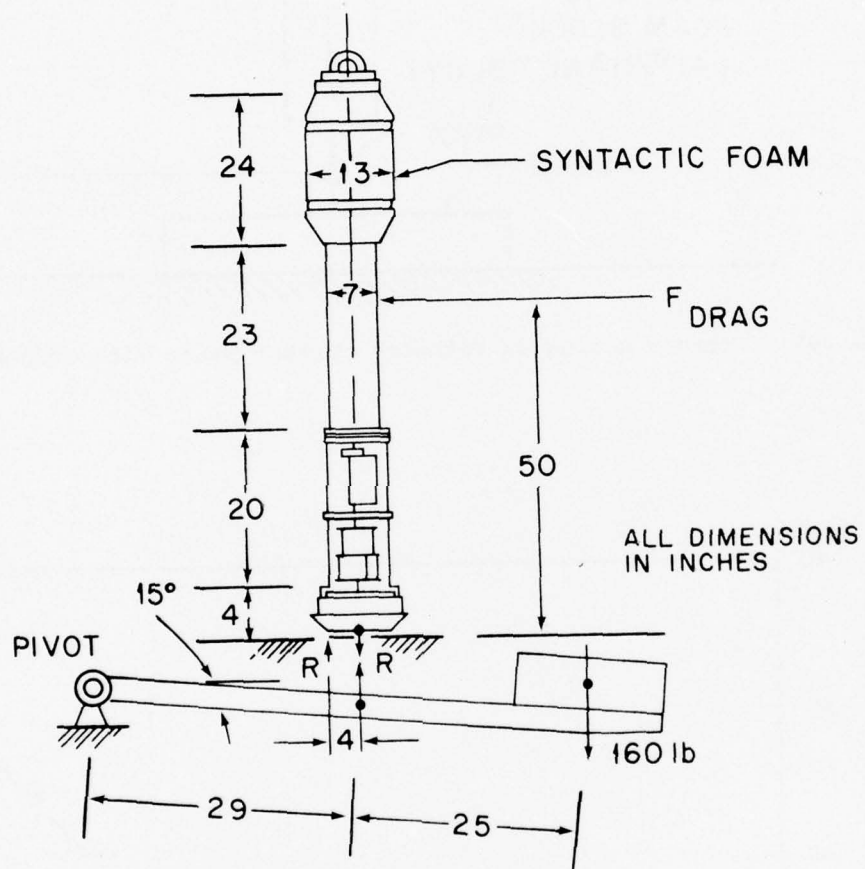


Figure 23B Floatation Required to Maintain Vertical Position of Tethered Current Meter With Offset Buoyancy Block



$$160 (29 + 25) \cos 15 = R (29 \cos 15)$$

$$R = 298 \text{ lb.}$$

$$F_{DRAG} (50) = 4R = 4(298)$$

$$F_{DRAG} = 24 \text{ lb.}$$

Figure 24 Forces on Pivoted Base Meter With Counter Weight

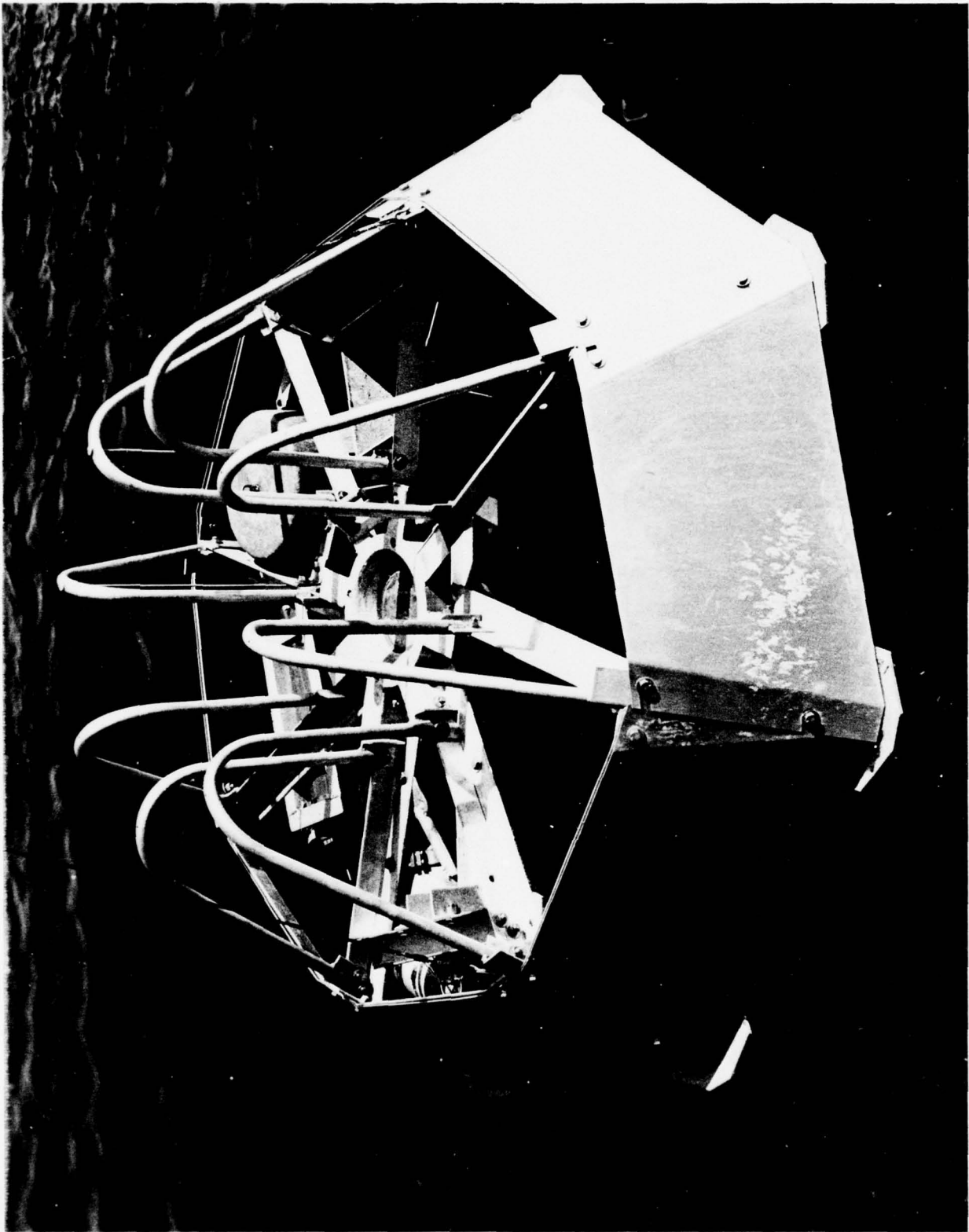


Figure 25 Top View of Mounting Base and Spider Assy.

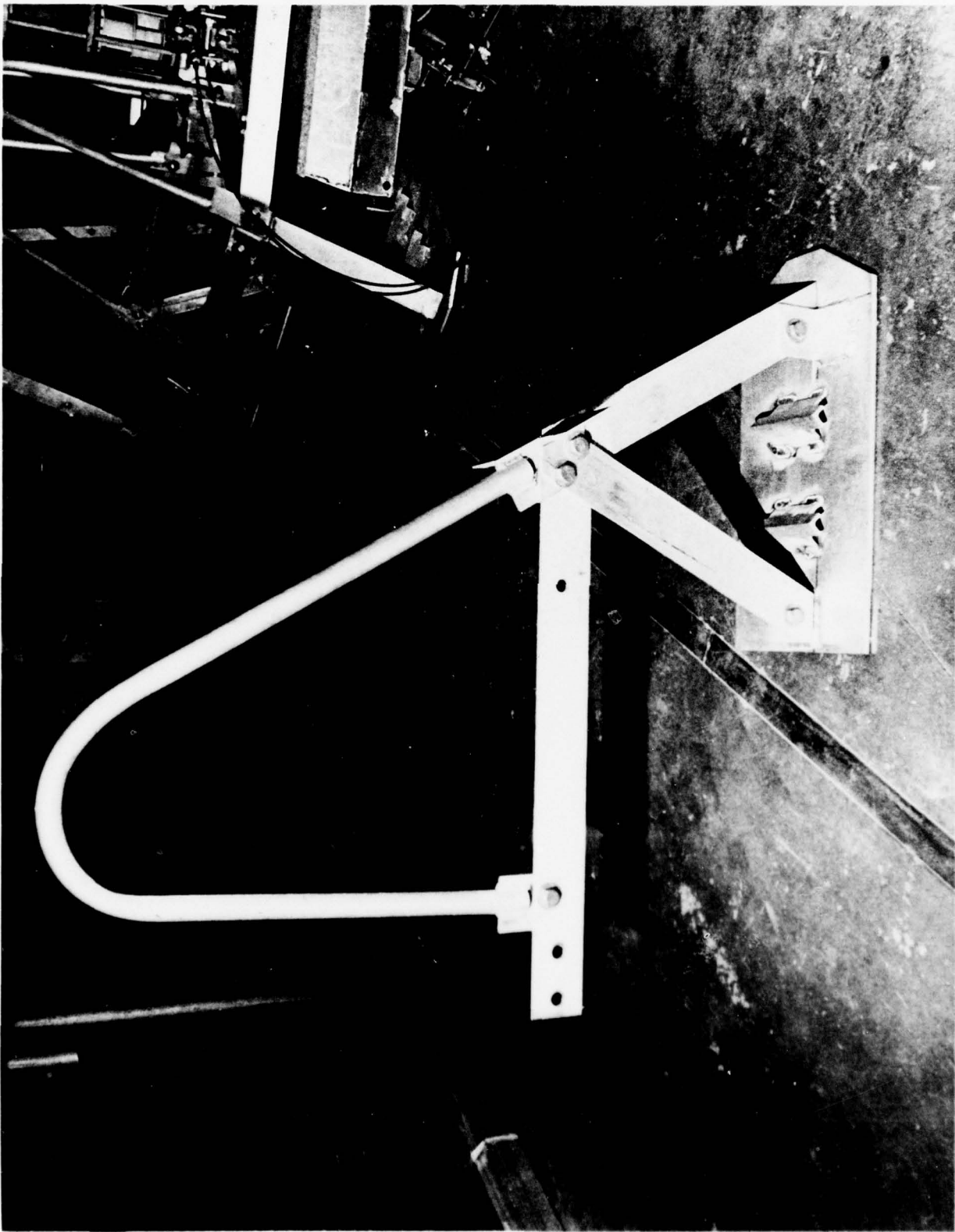


Figure 26 Typical Deflector Bar and Foot Assy.

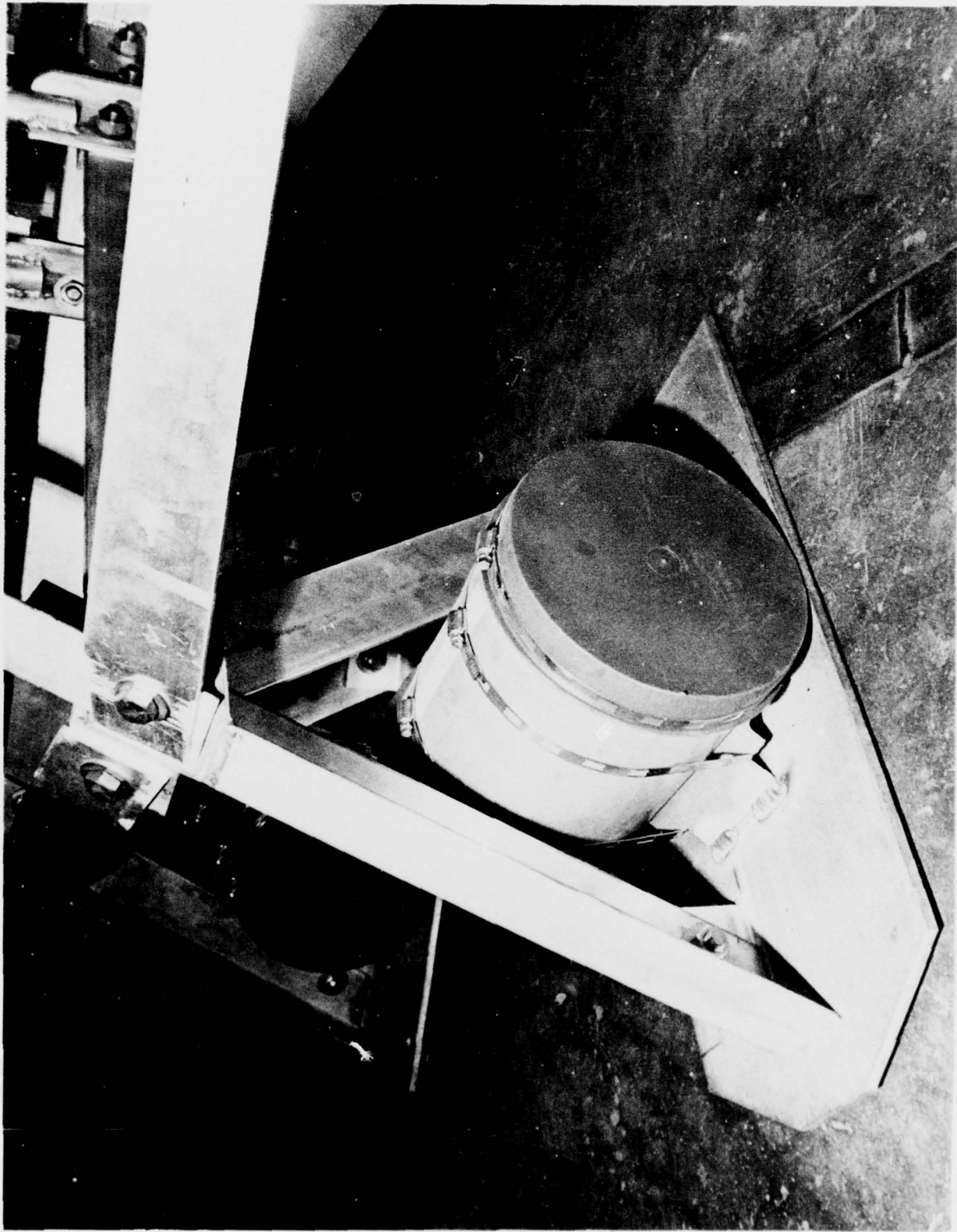


Figure 27 Cylindrical Sand Filled Ballast Weights

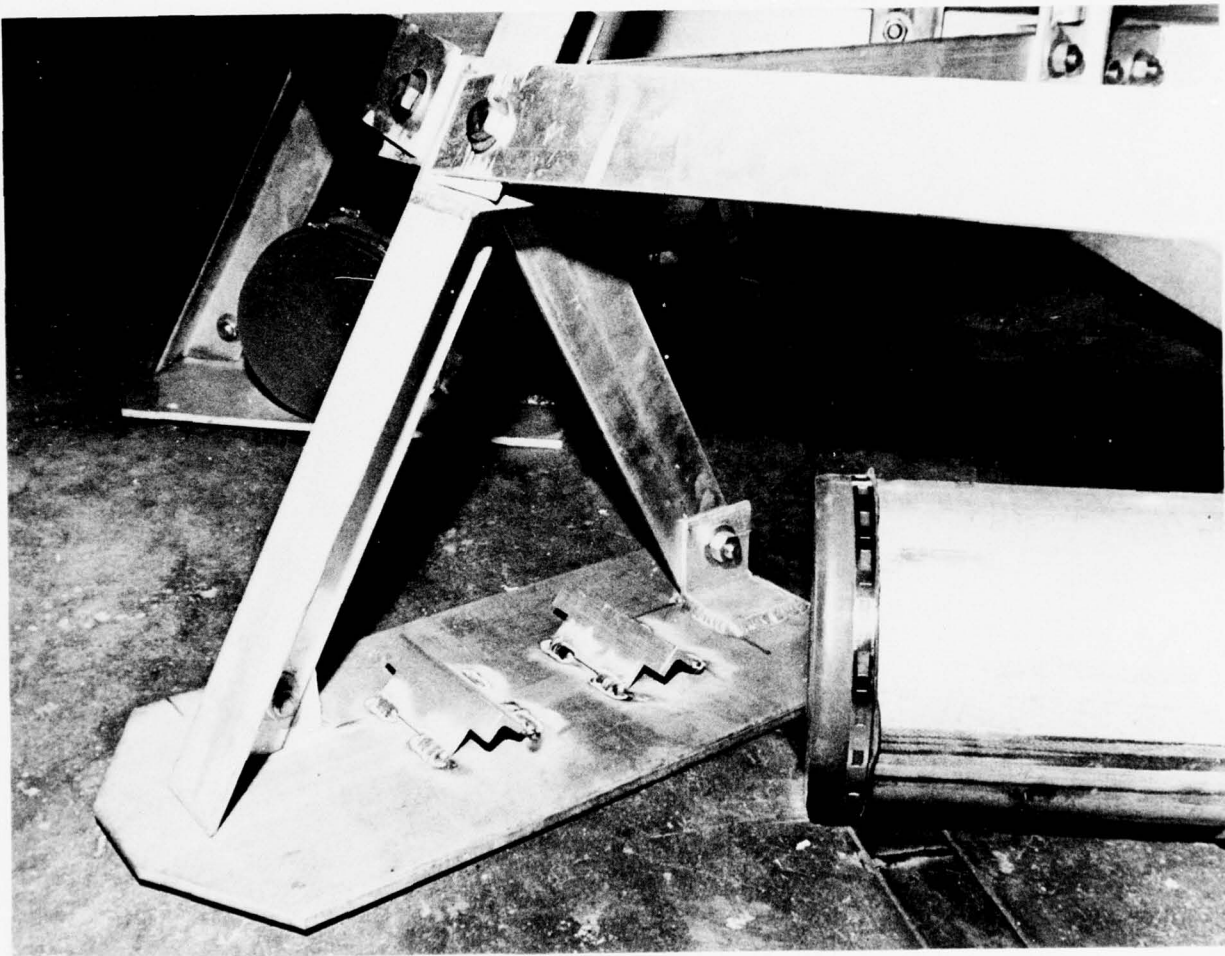


Figure 28      Ballast Weight Saddle Mounts

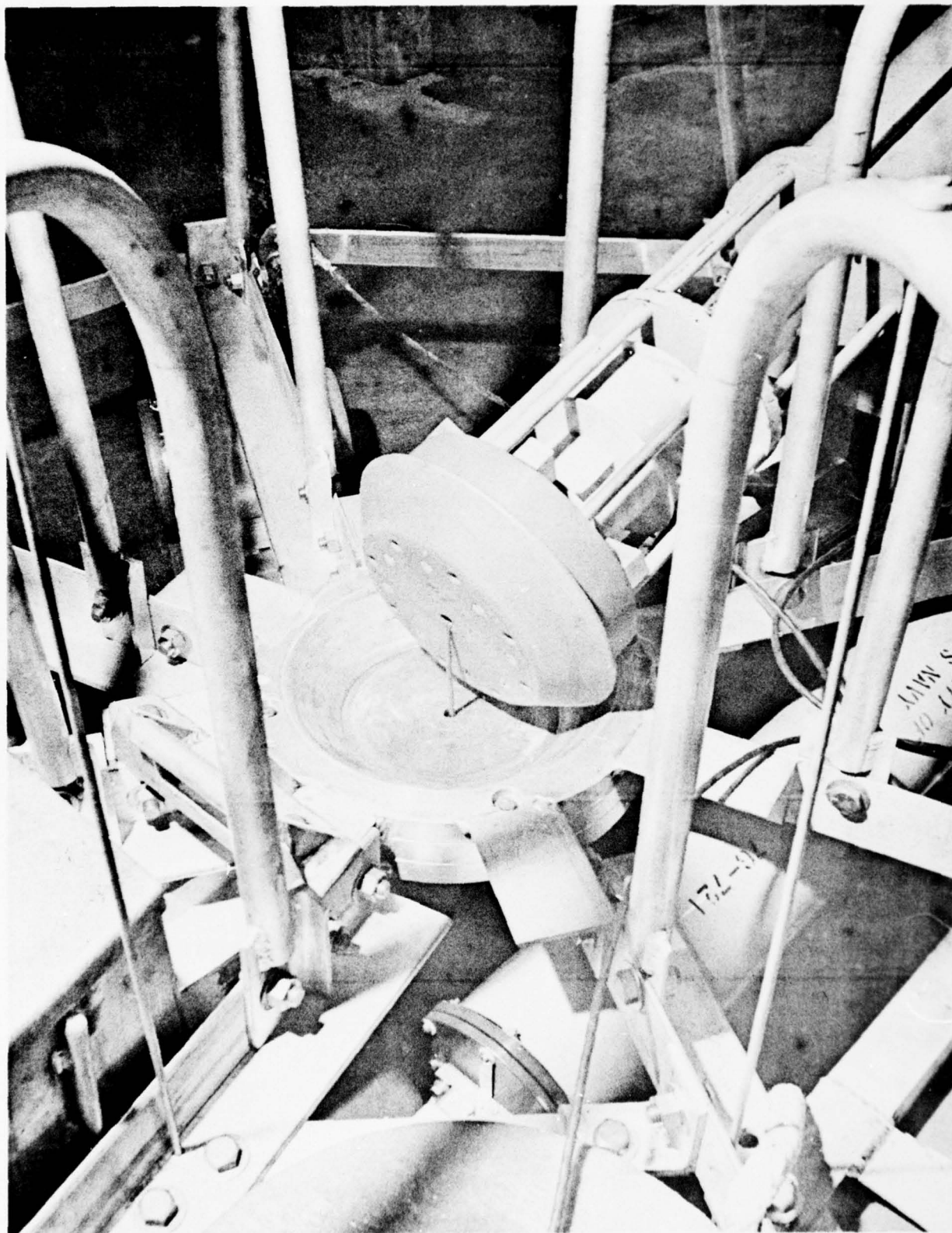


Figure 29 Conical Mounting Base and Flexible Attachment Cable

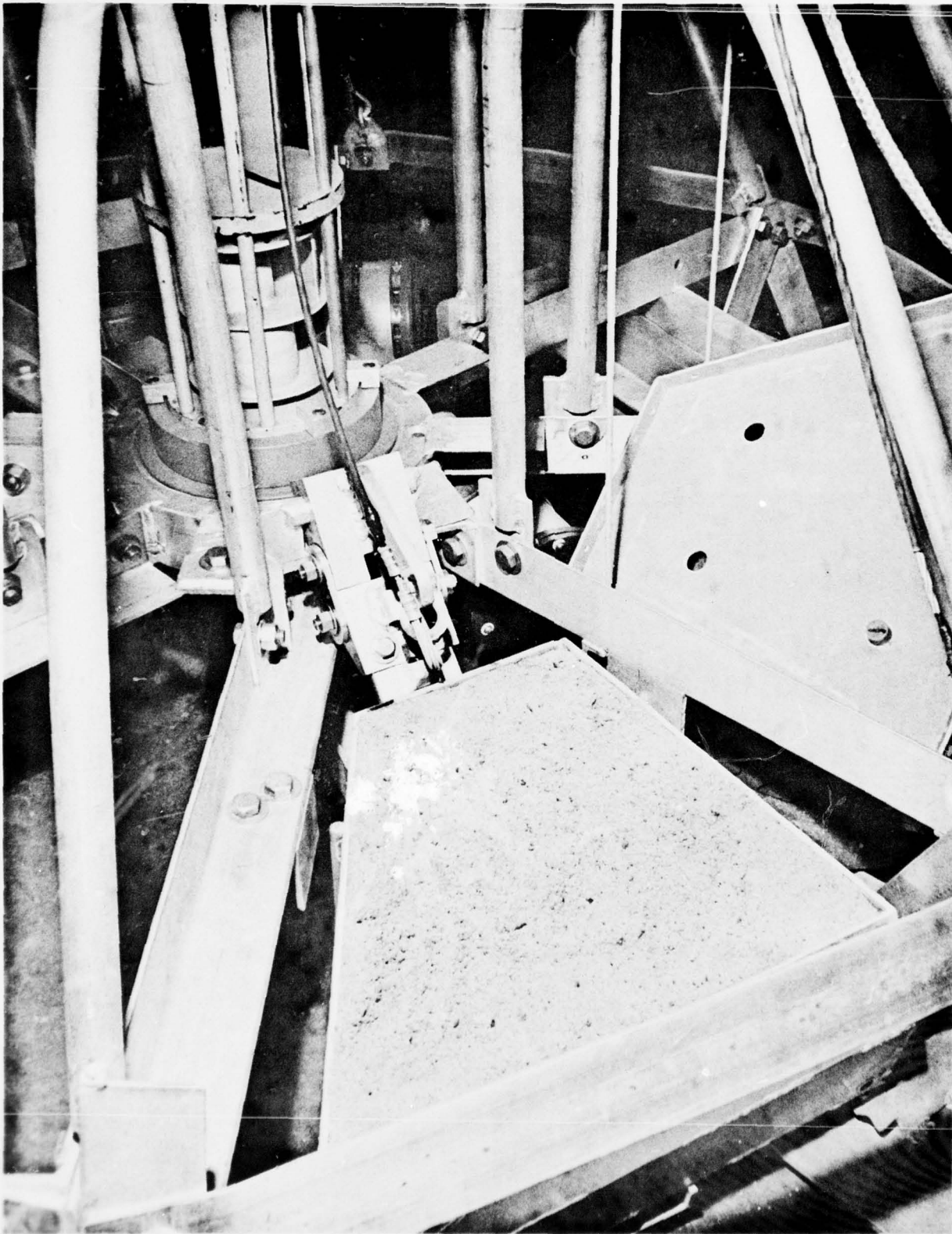


Figure 30 Counter Weight Sand Ballast Container

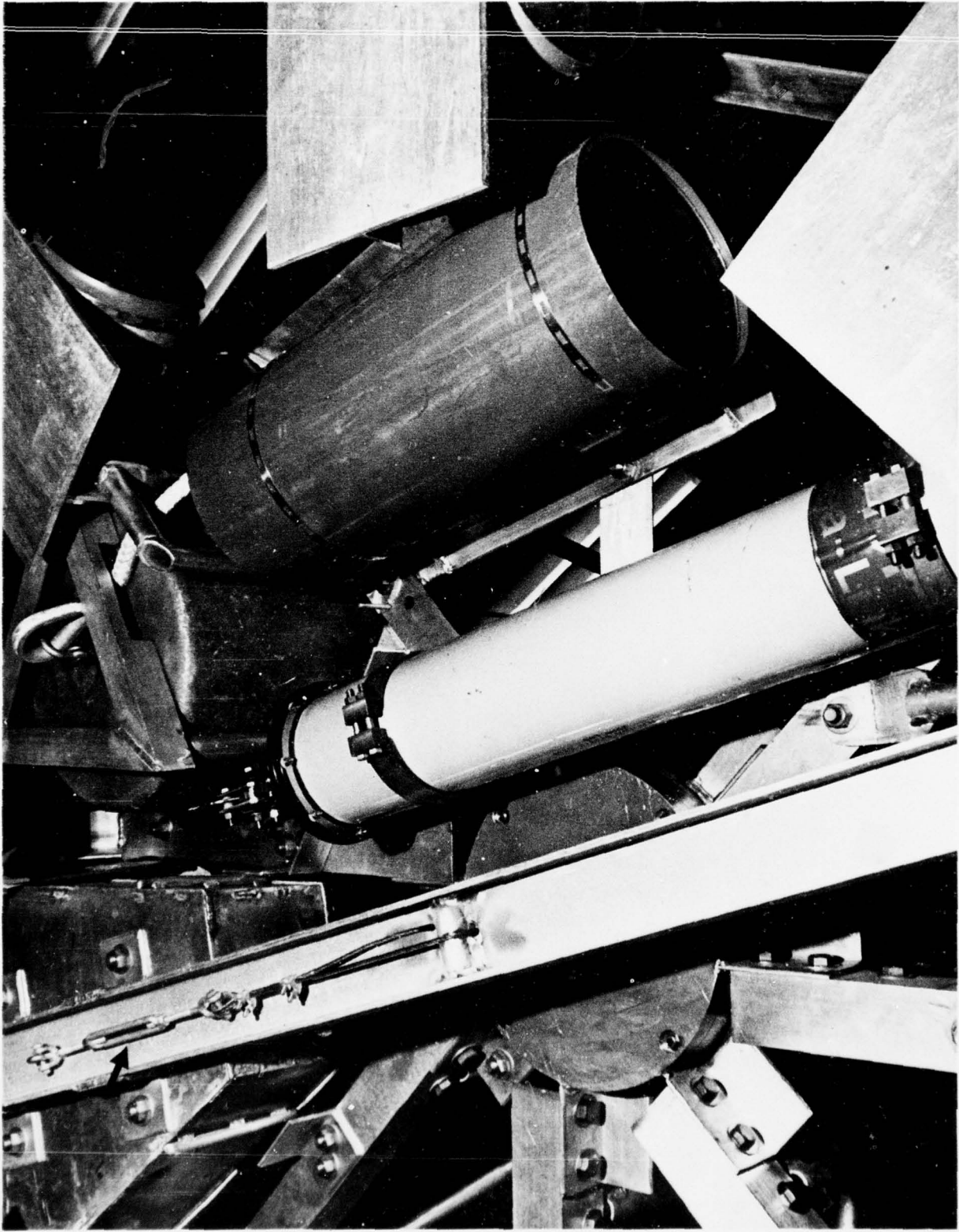


Figure 31 Stainless Steel Hinge Cable Adjustment At Base of Lever Arm

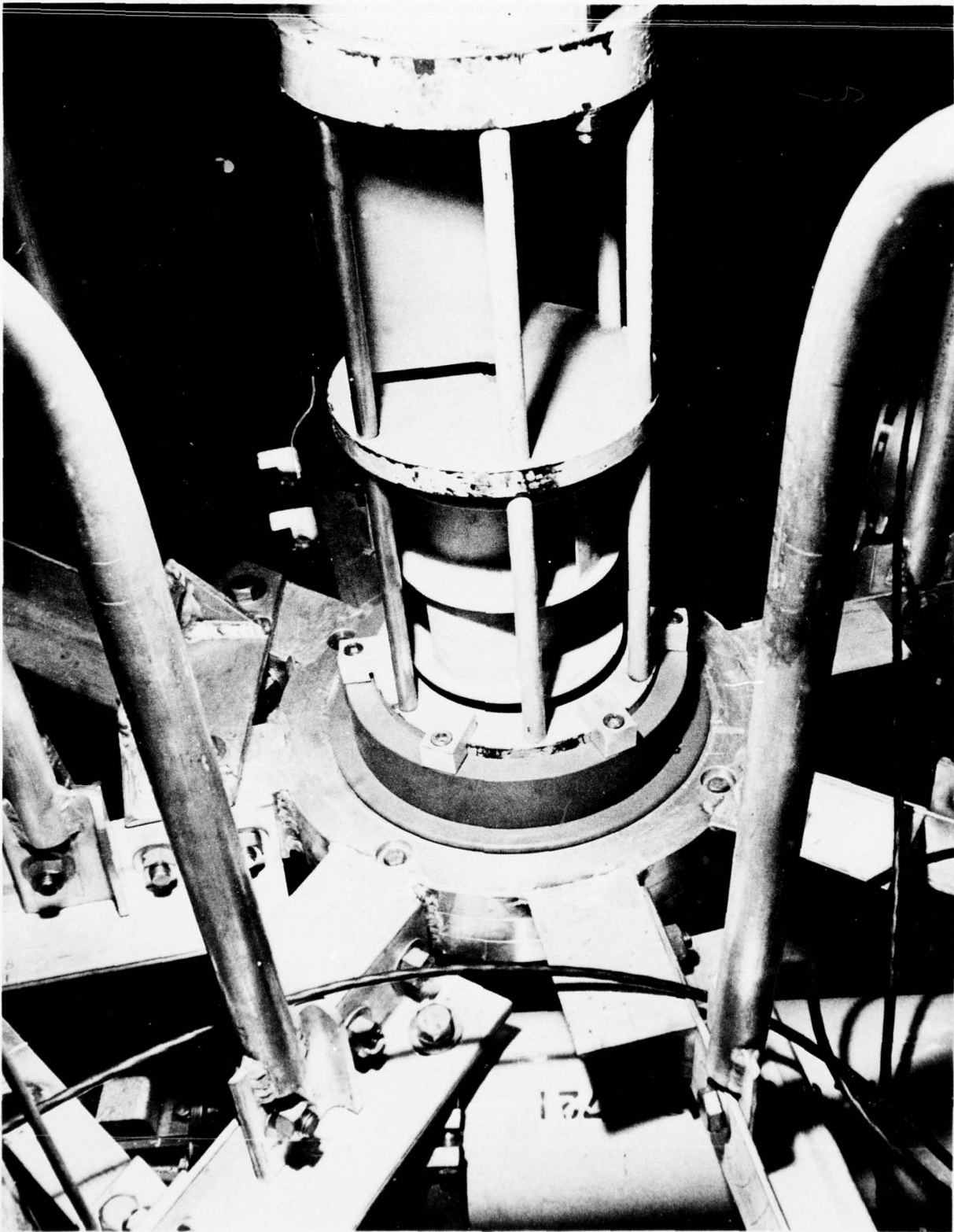


Figure 32      Current Meter Attachment Clamp Tabs

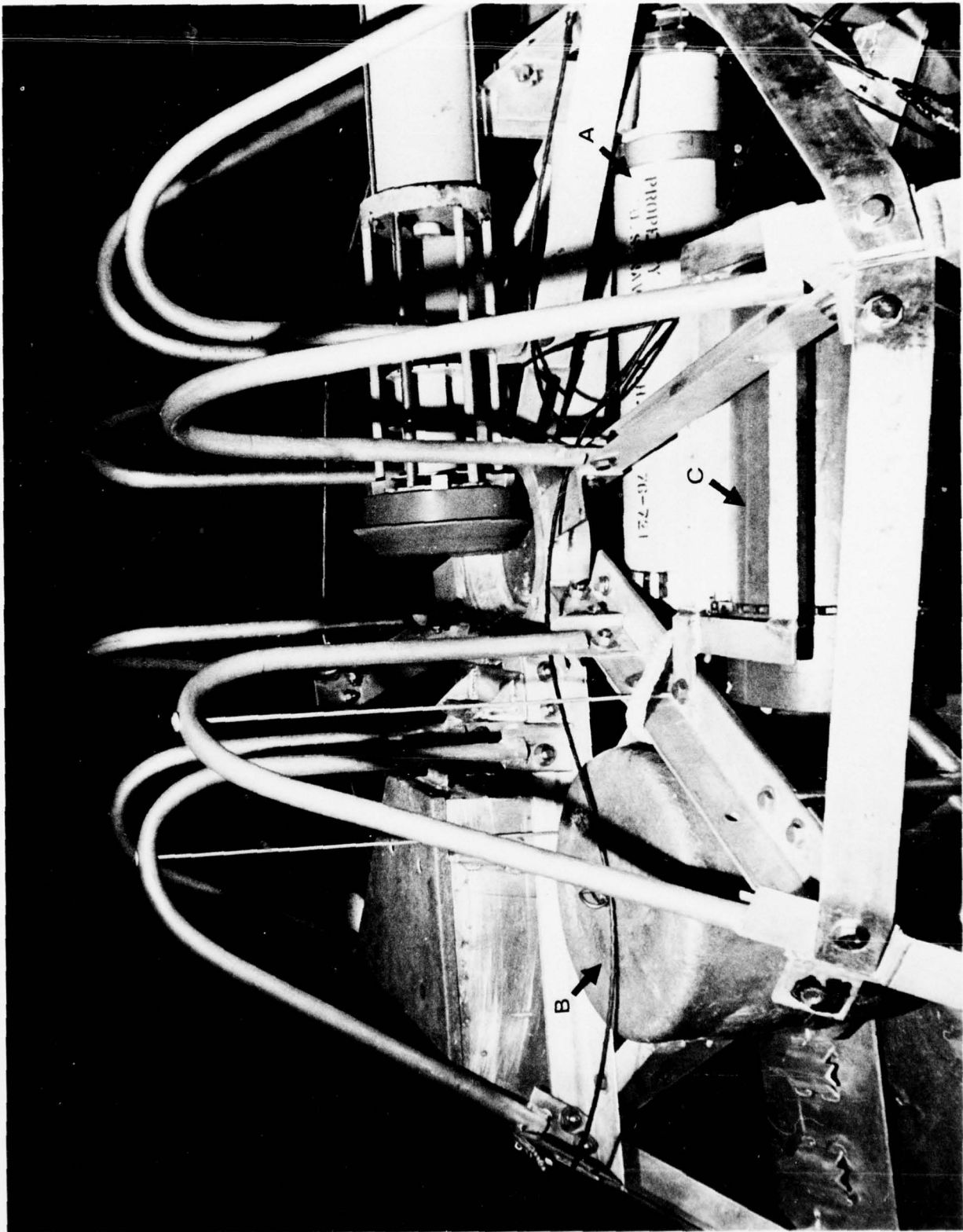


Figure 33 Surface Float and AMF 314 Release Mechanism

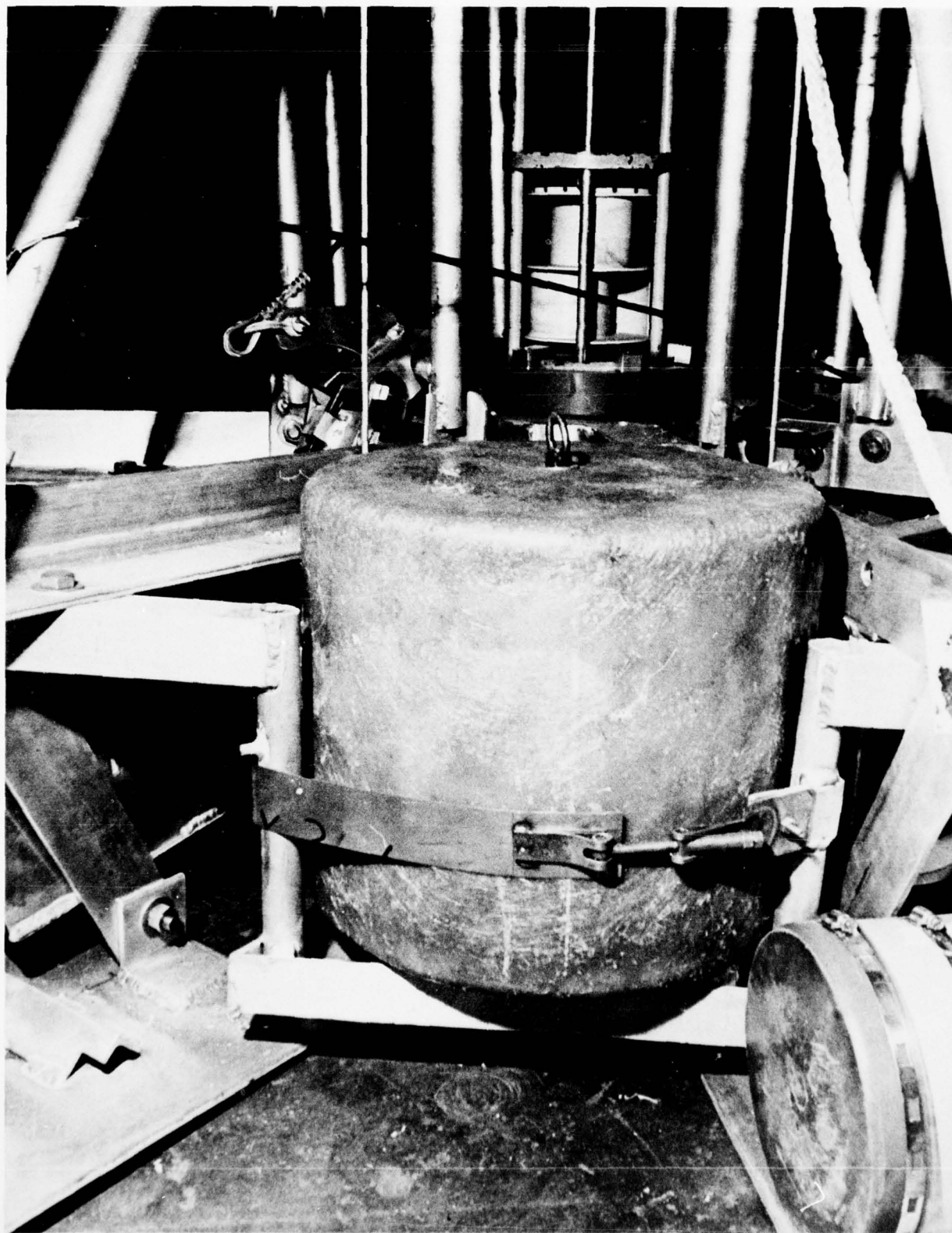


Figure 34      Recovery Float and Release-Locking Band

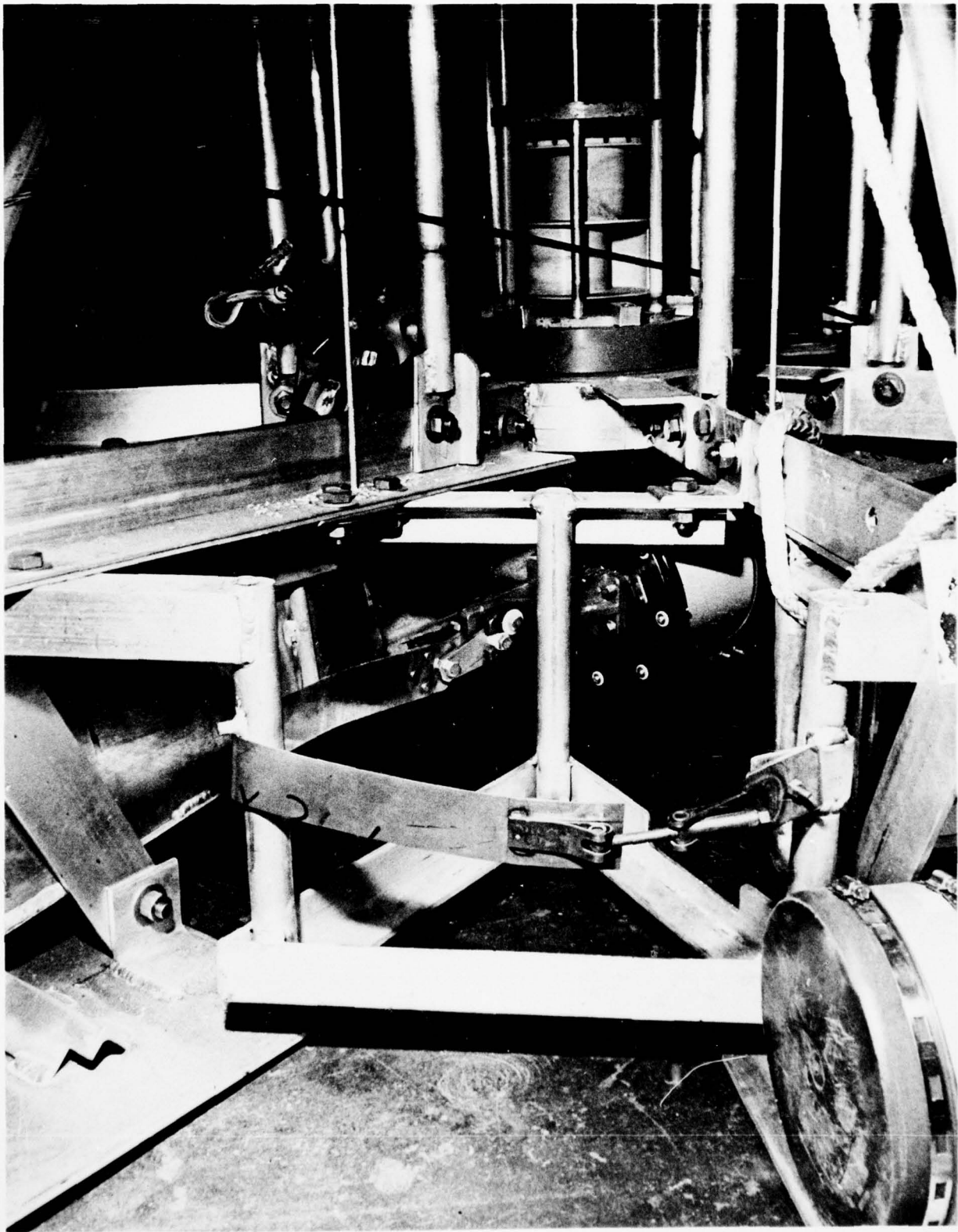


Figure 35      Float Locking Band and Armed AMF 314 Release Mechanism

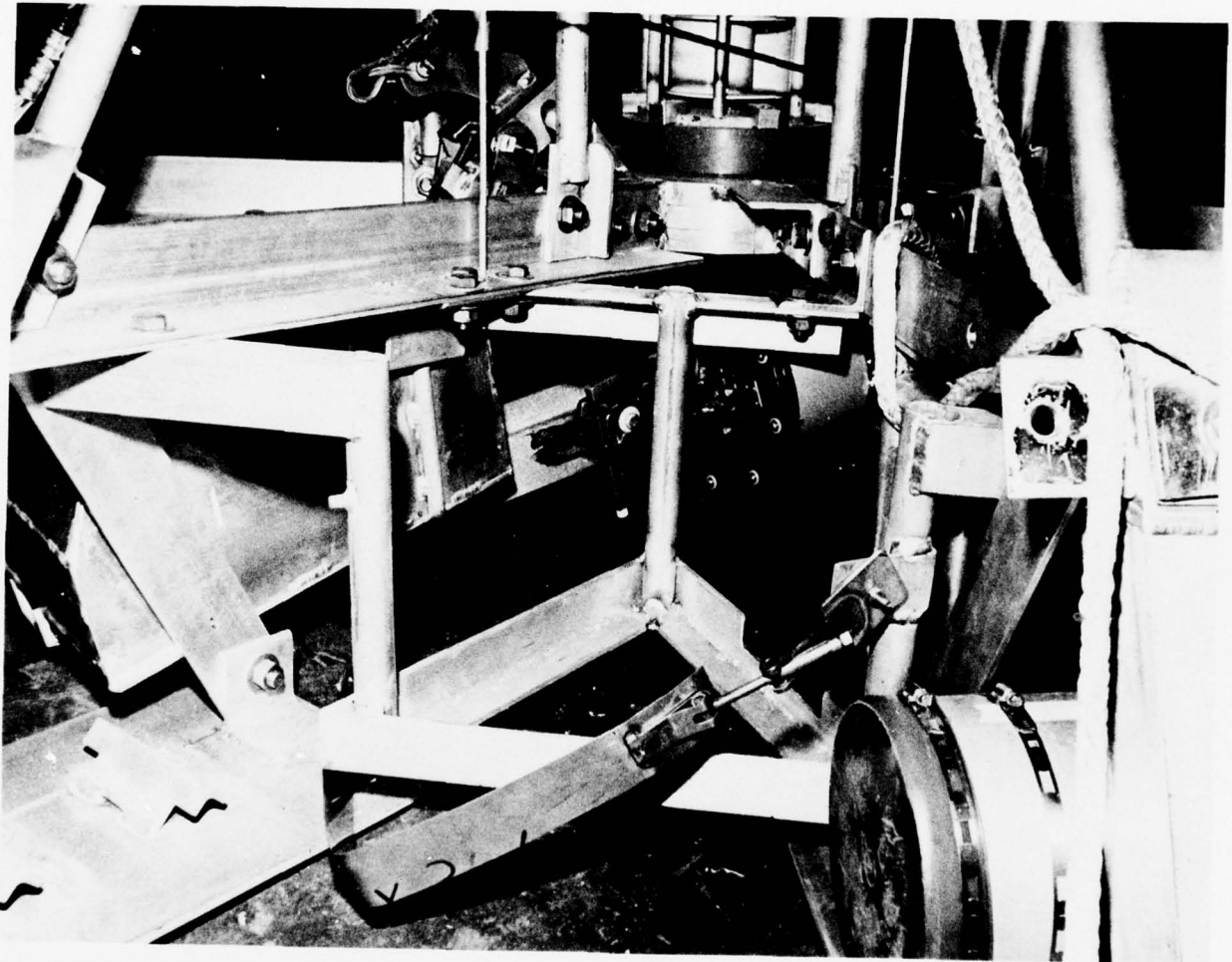


Figure 36     Float Locking Band in Released Position



Figure 37     Band Clamp and Surface Float Locking Detent Modification

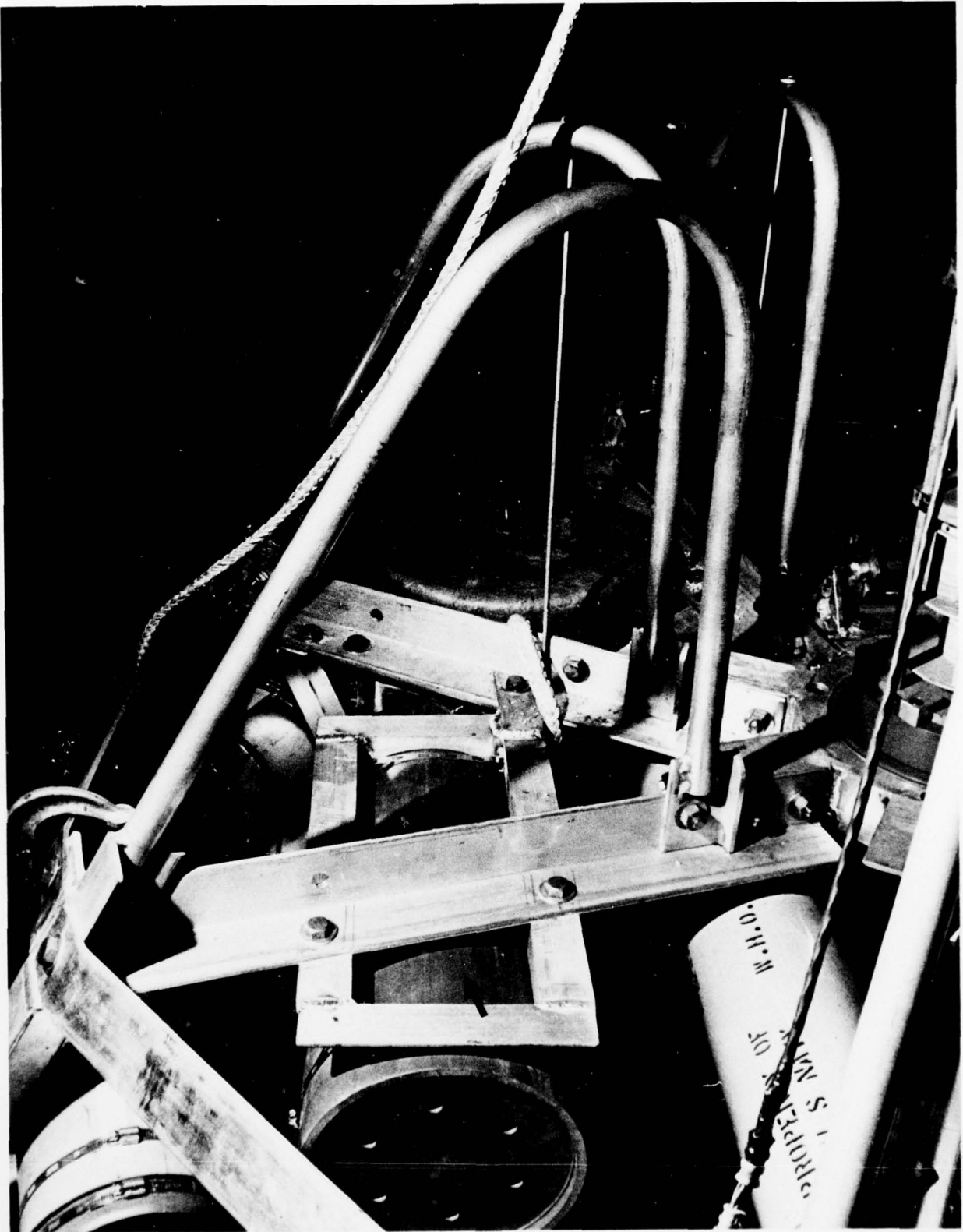


Figure 38 Recovery Line Storage Canister Mounting Location

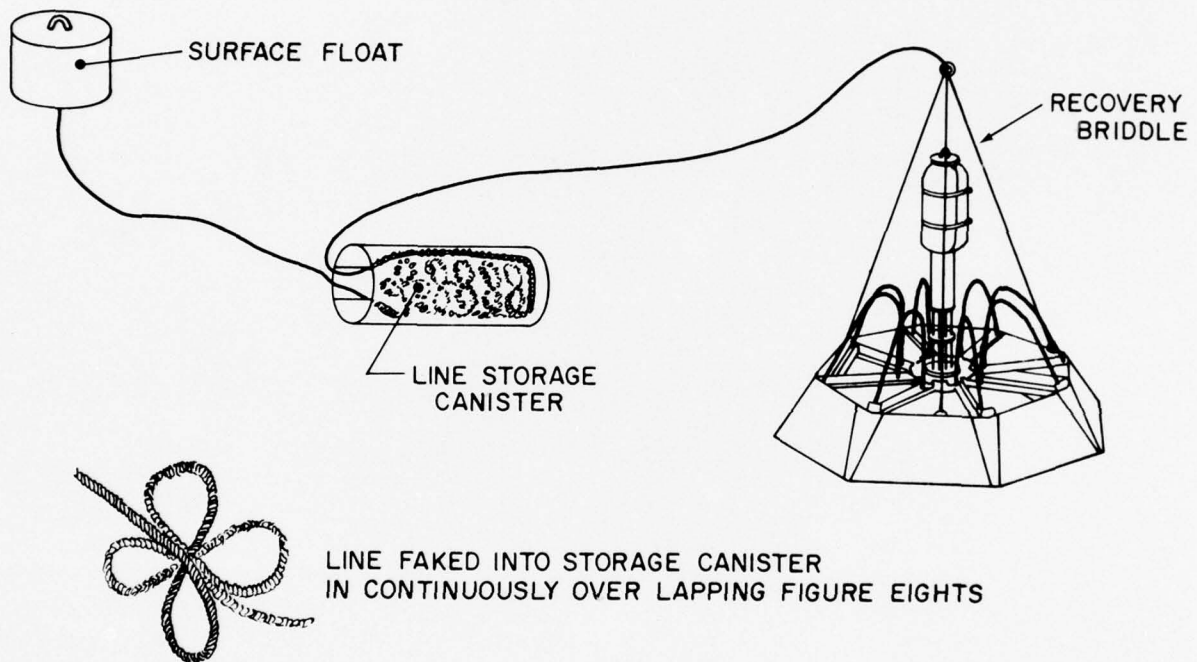


Figure 39 Recovery Line Packing Method and Attachment Points for Float and Lift Bridle

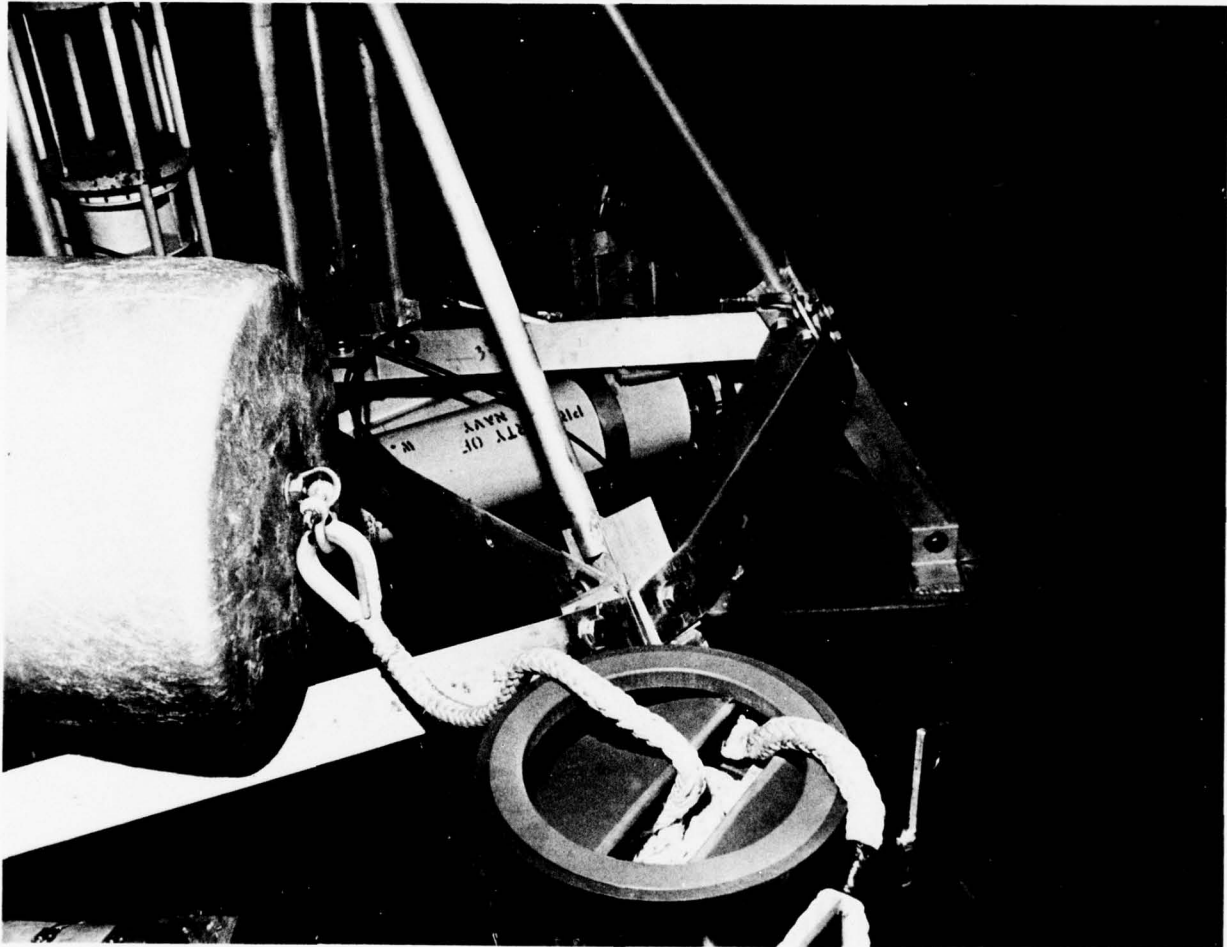


Figure 40      Recovery Line Canister and Retainer Baffle

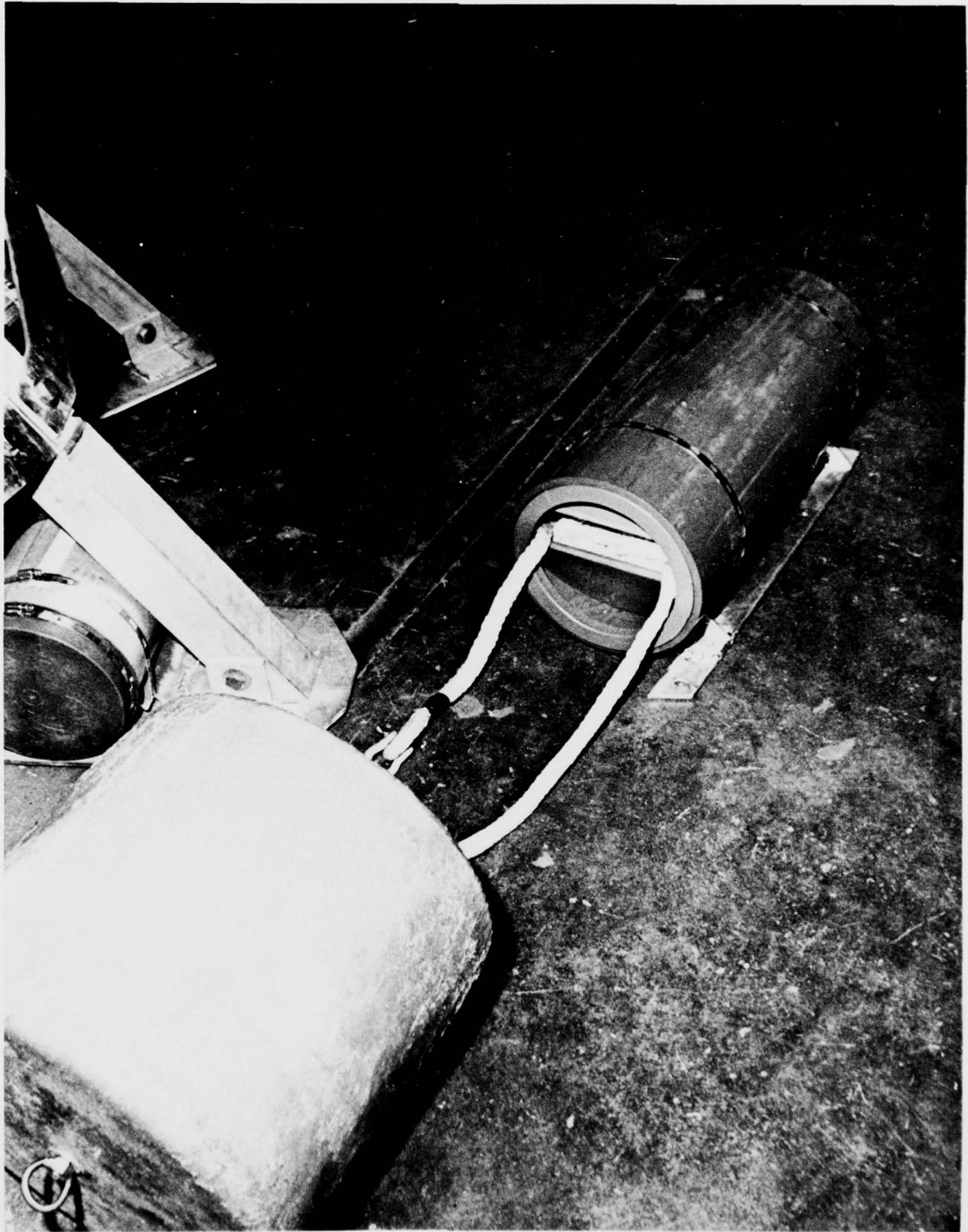


Figure 41      Line Canister Packed for Release Deployment

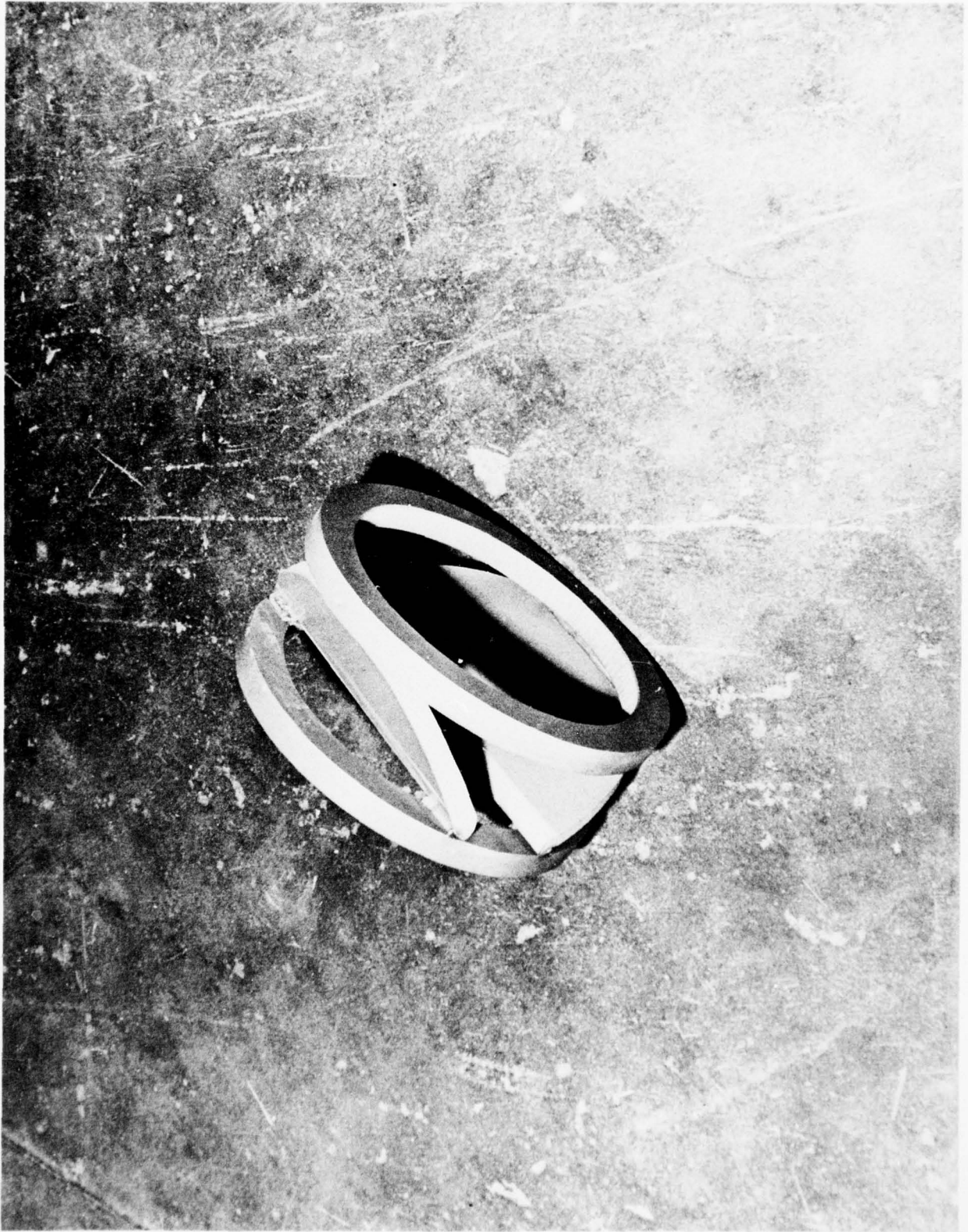


Figure 42 Construction Detail of Retainer Baffle

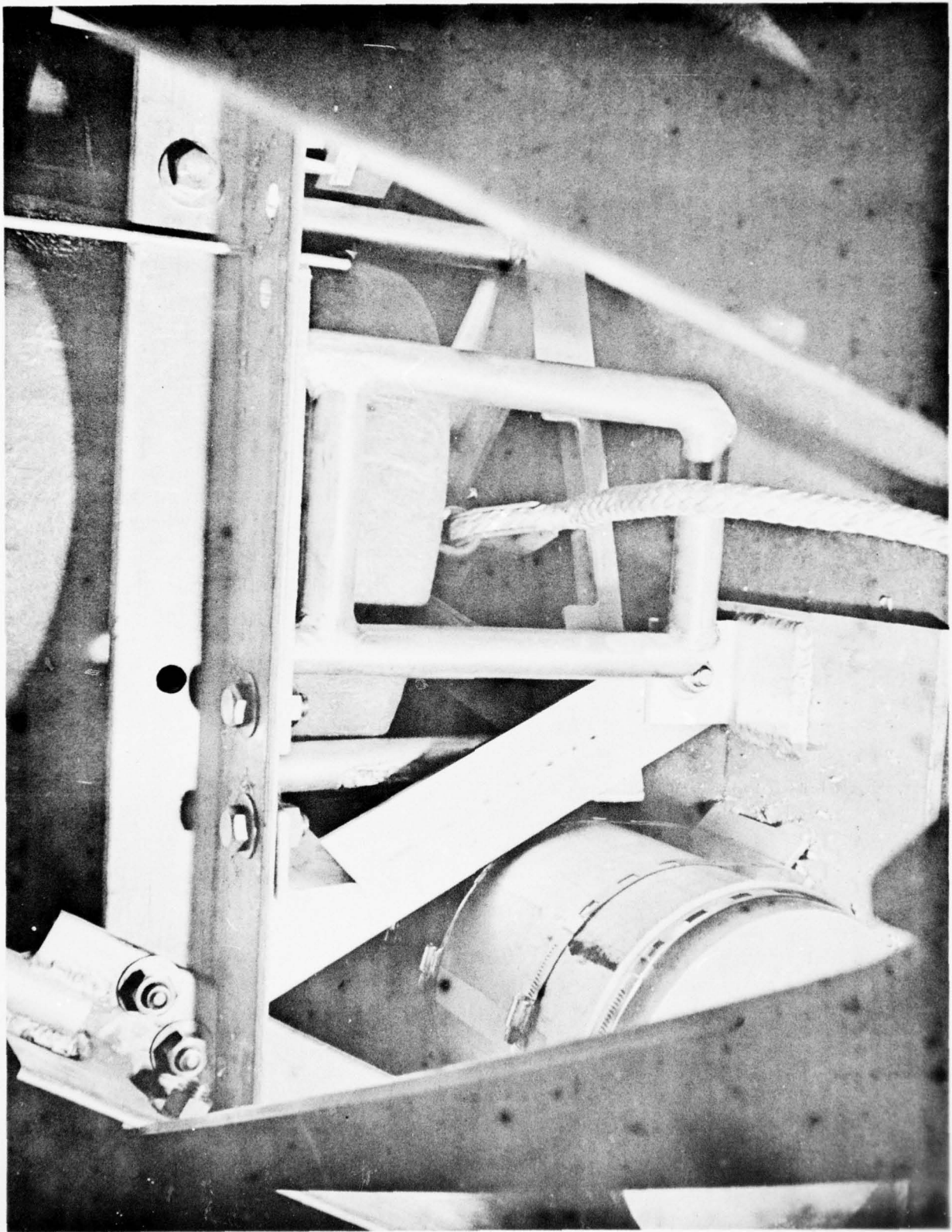


Figure 43 Line Fair Lead and Recovery Float Attachment Point

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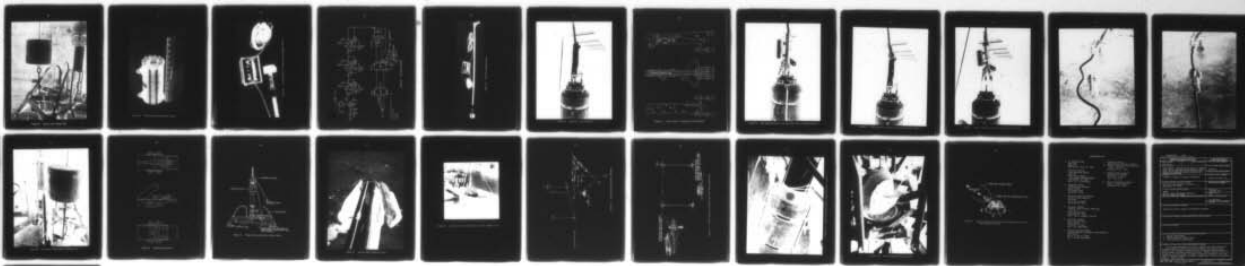
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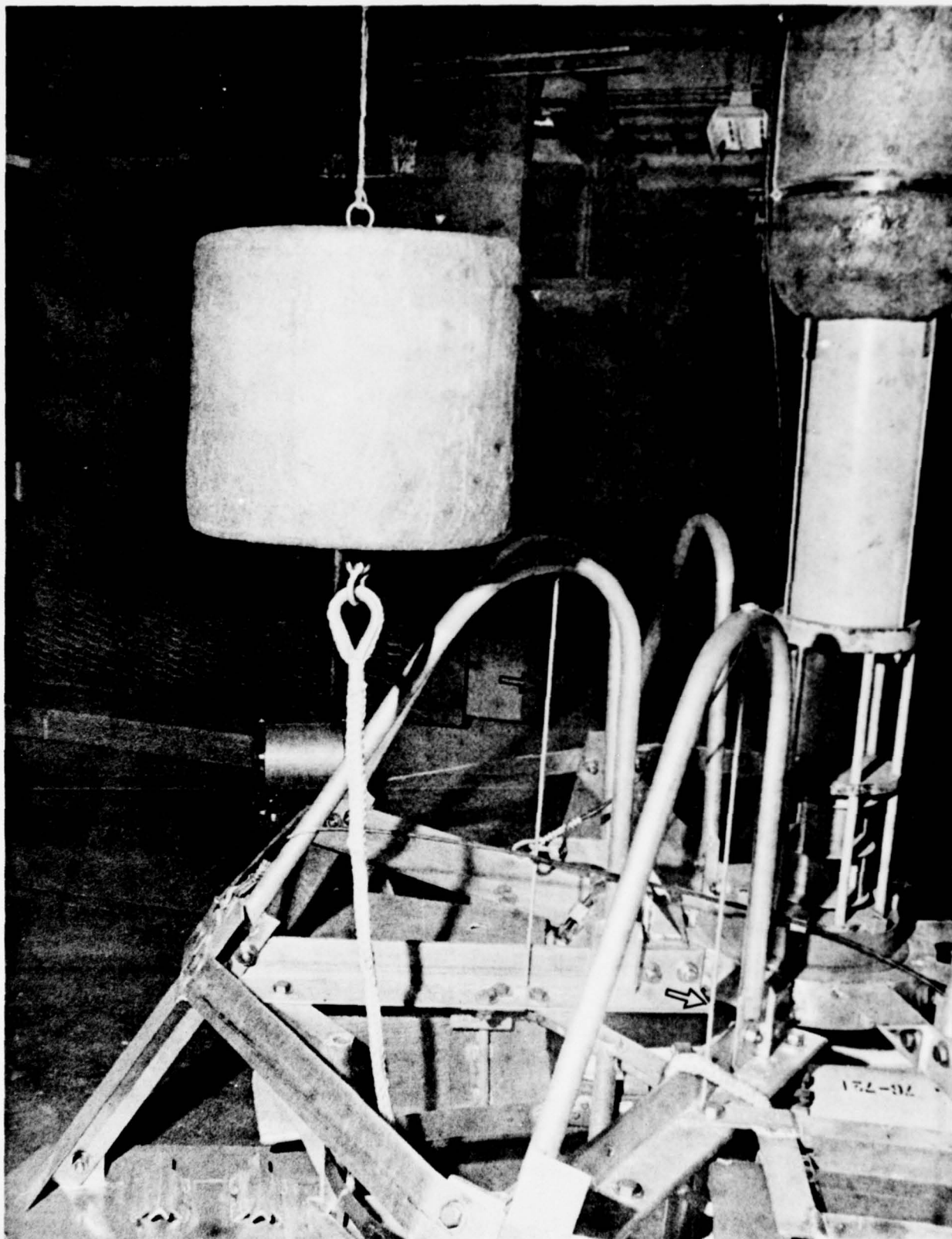


Figure 44 Typical Float Release Mode

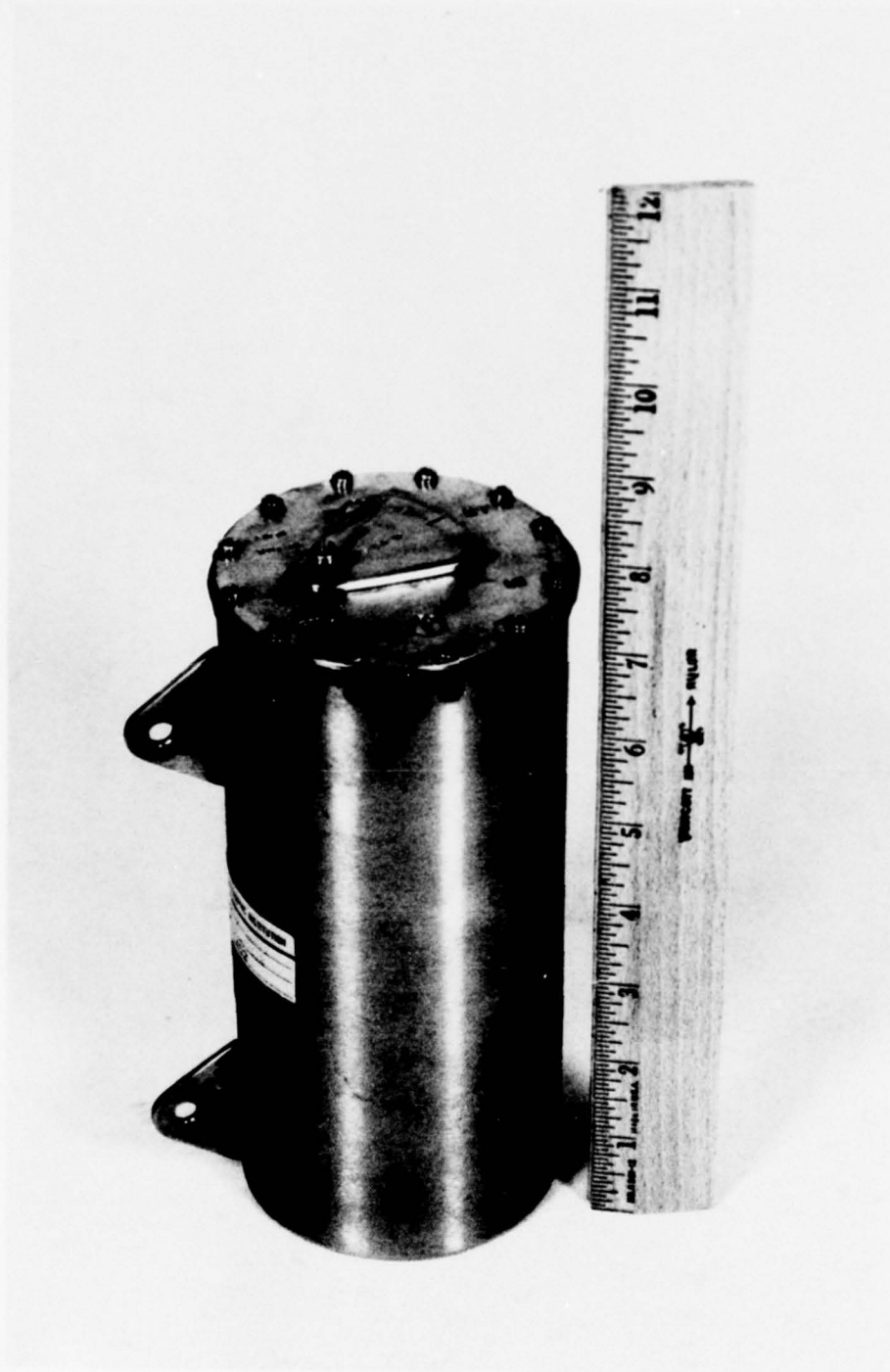


Figure 45      Vertical Indicating Acoustic Pinger

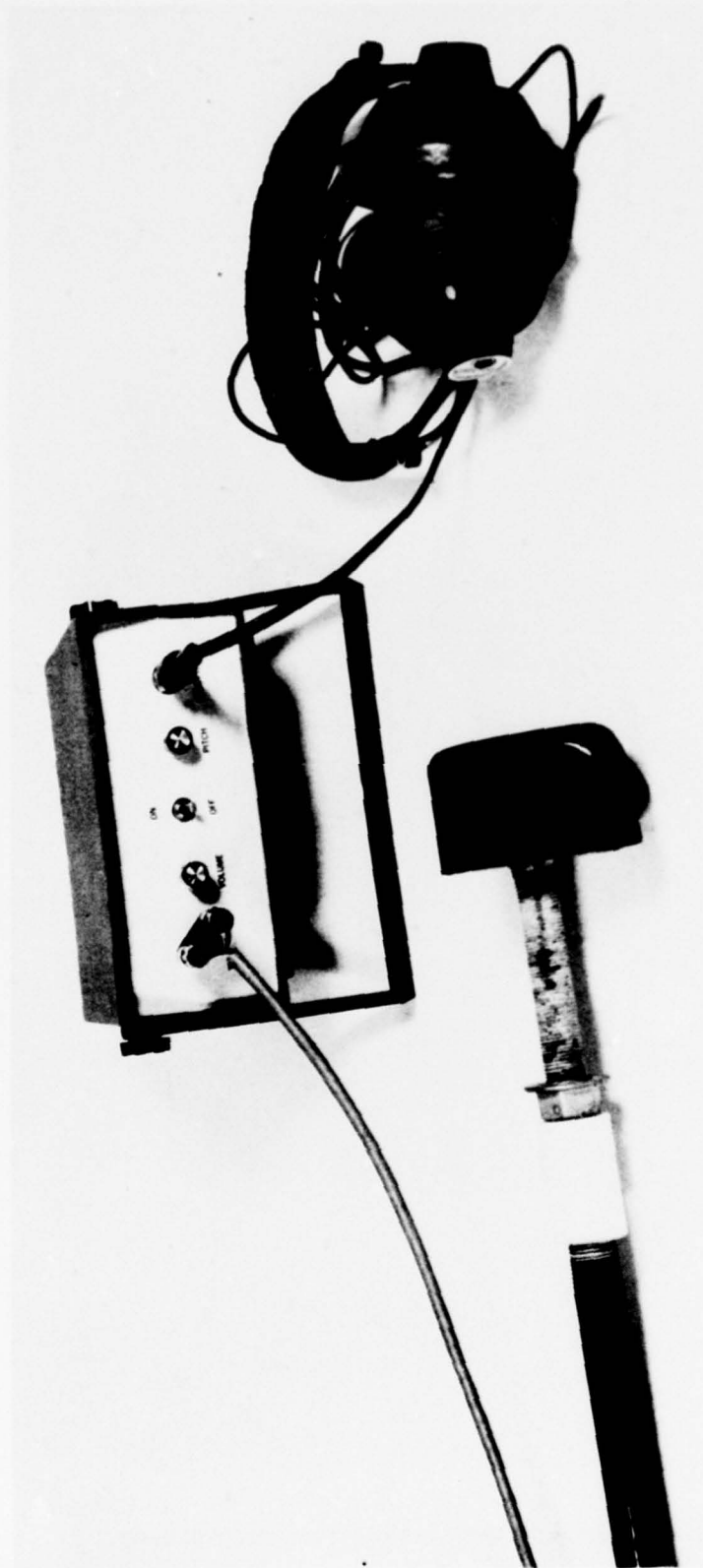


Figure 46 50 Khz Receiver, Ear Phones, and Transducer Pick Up

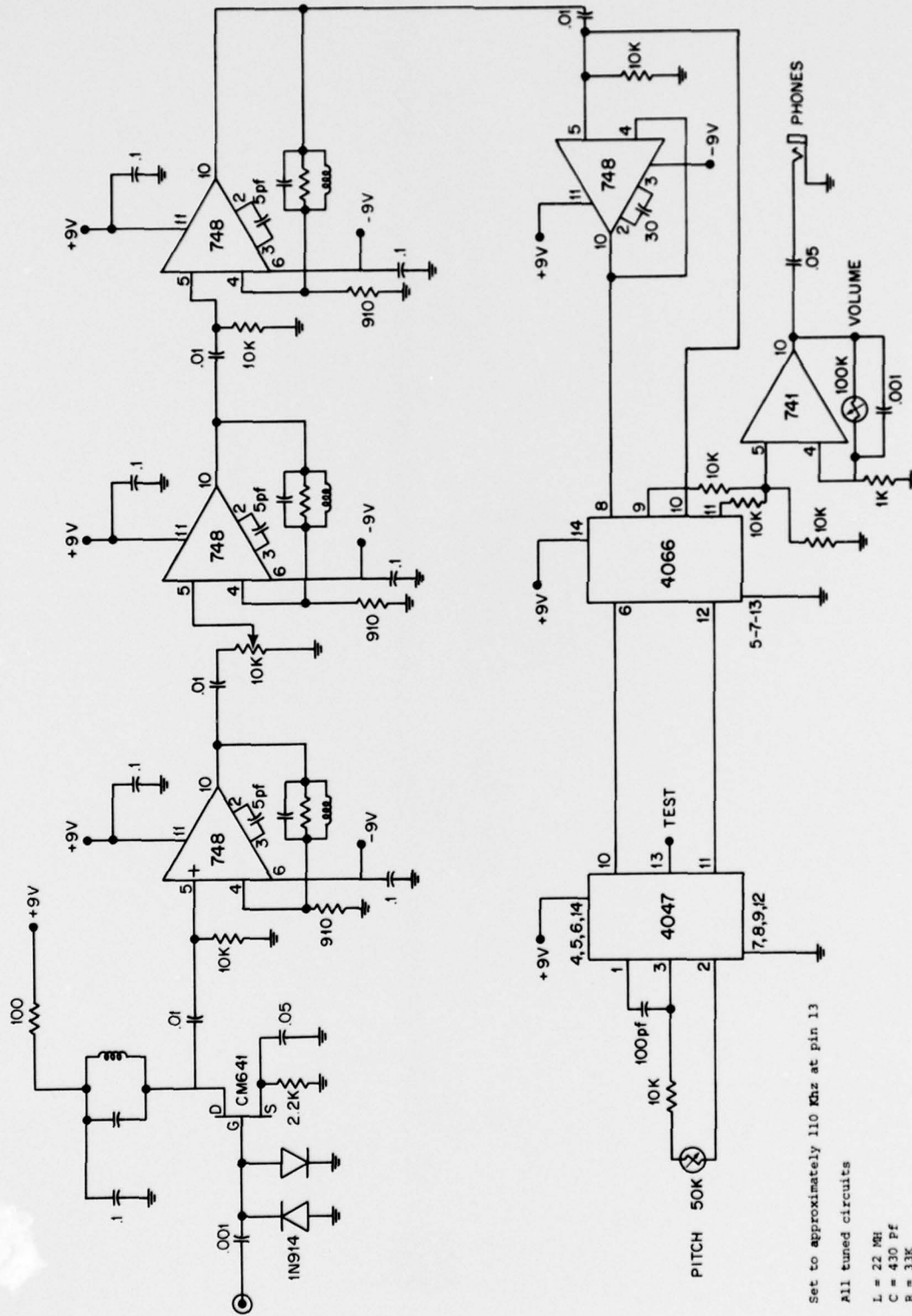


Figure 47 Receiver Schematic

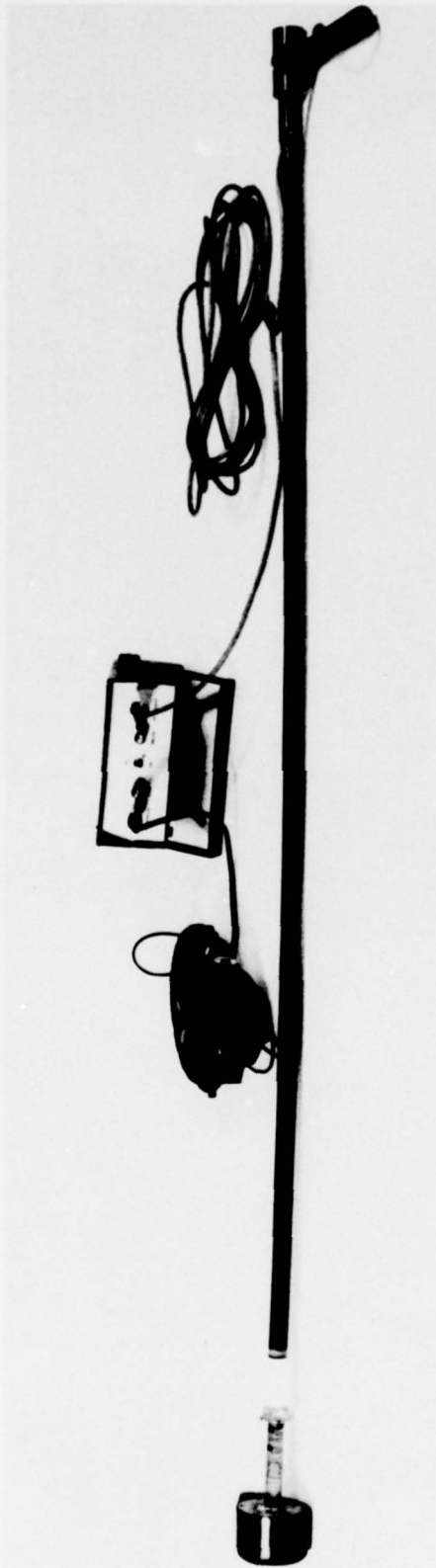


Figure 48 Receiver Transducer Assy.

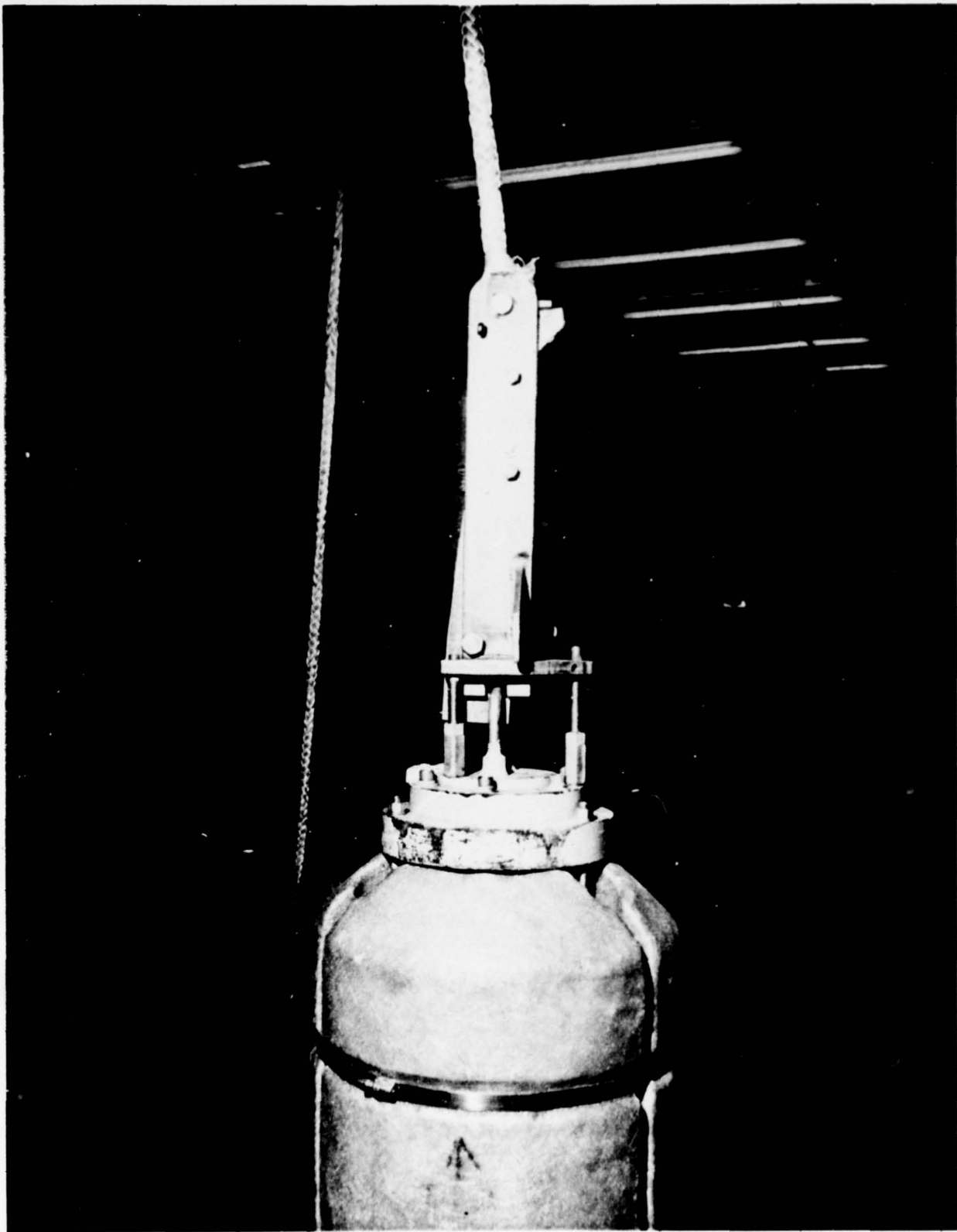


Figure 49      Mechanical Trip Mechanism

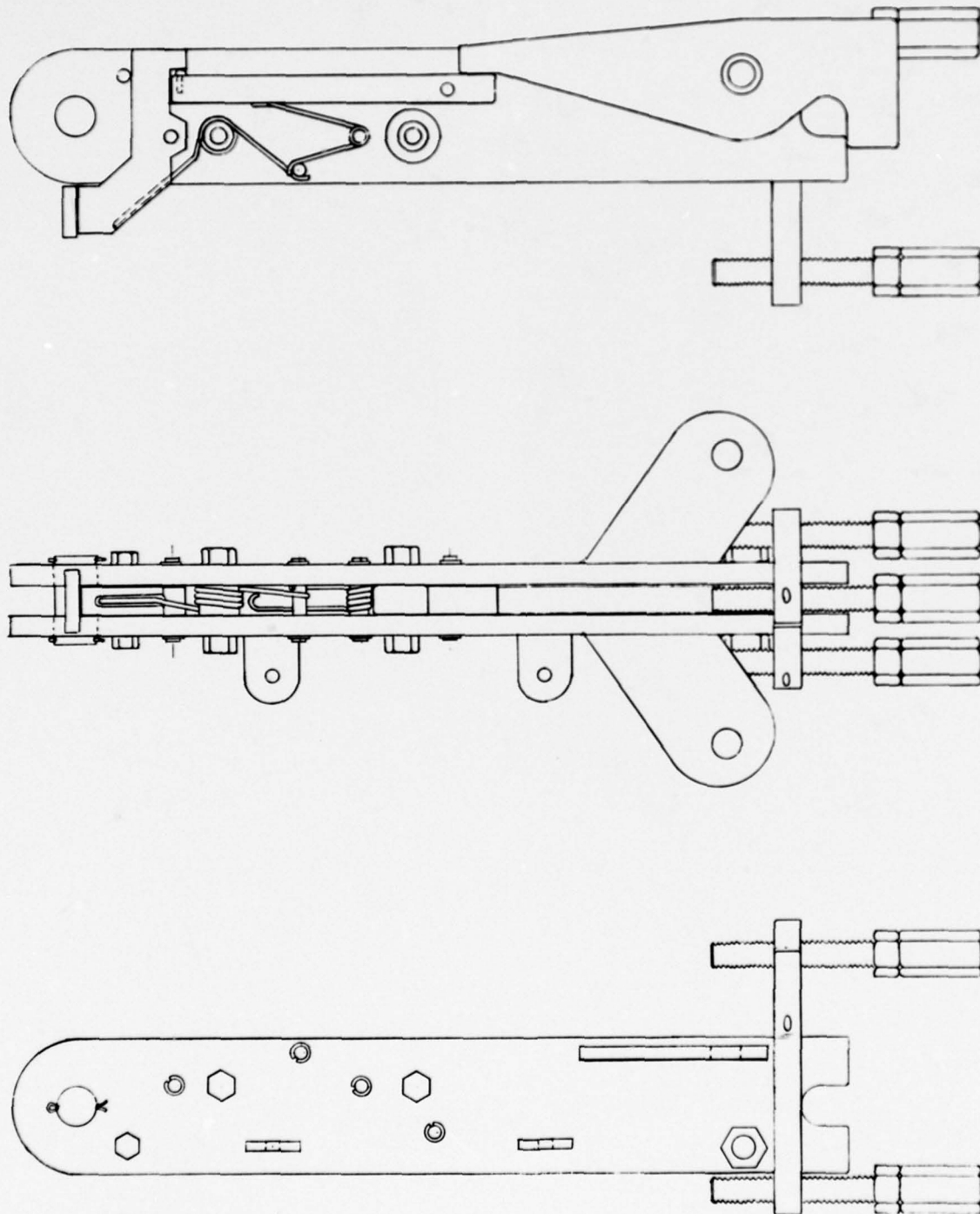


Figure 50 · Cross Section of Mechanical Trip Mechanism

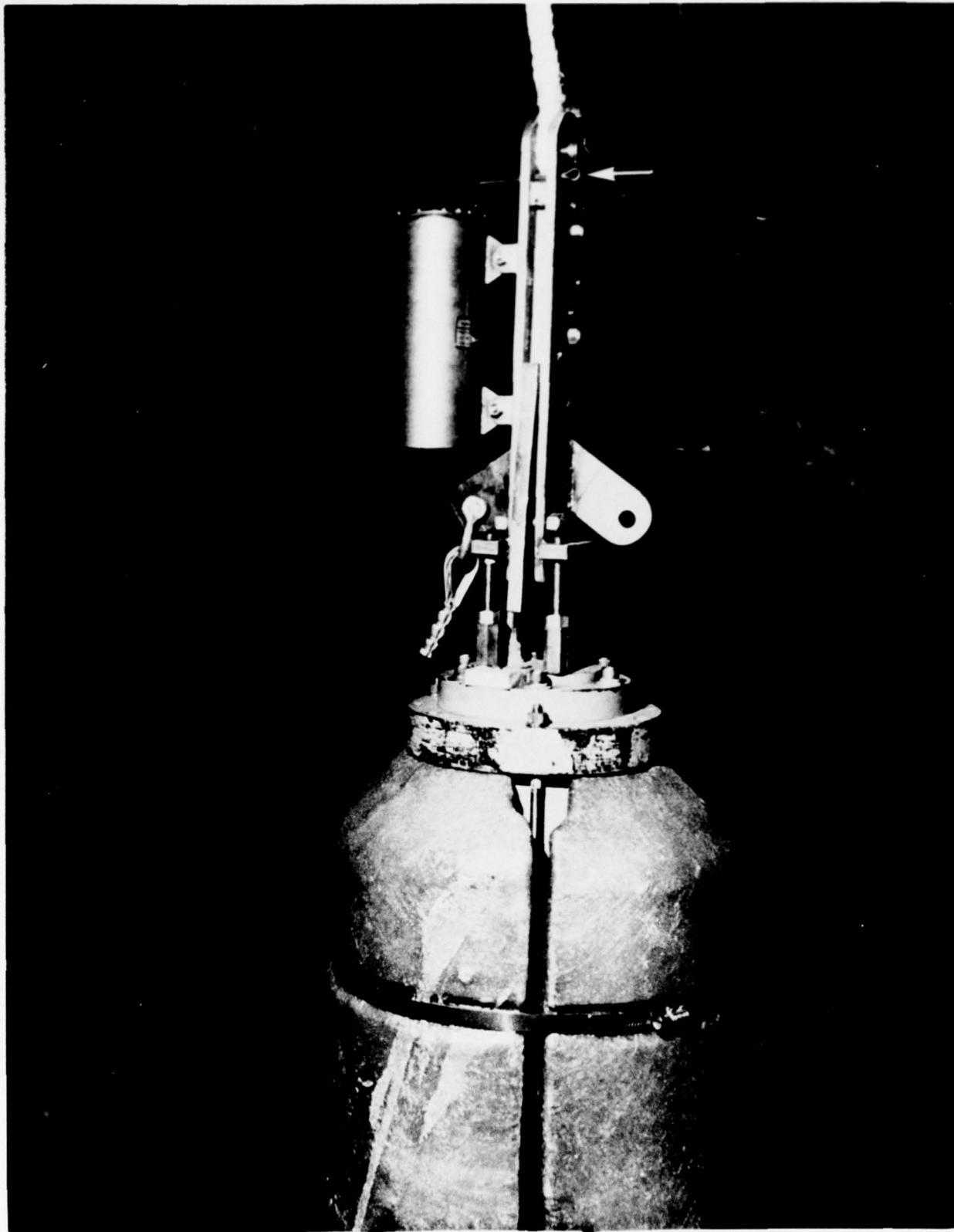


Figure 51 Trip Mechanism Safety Lock and Finger Assy. in Cocked Position

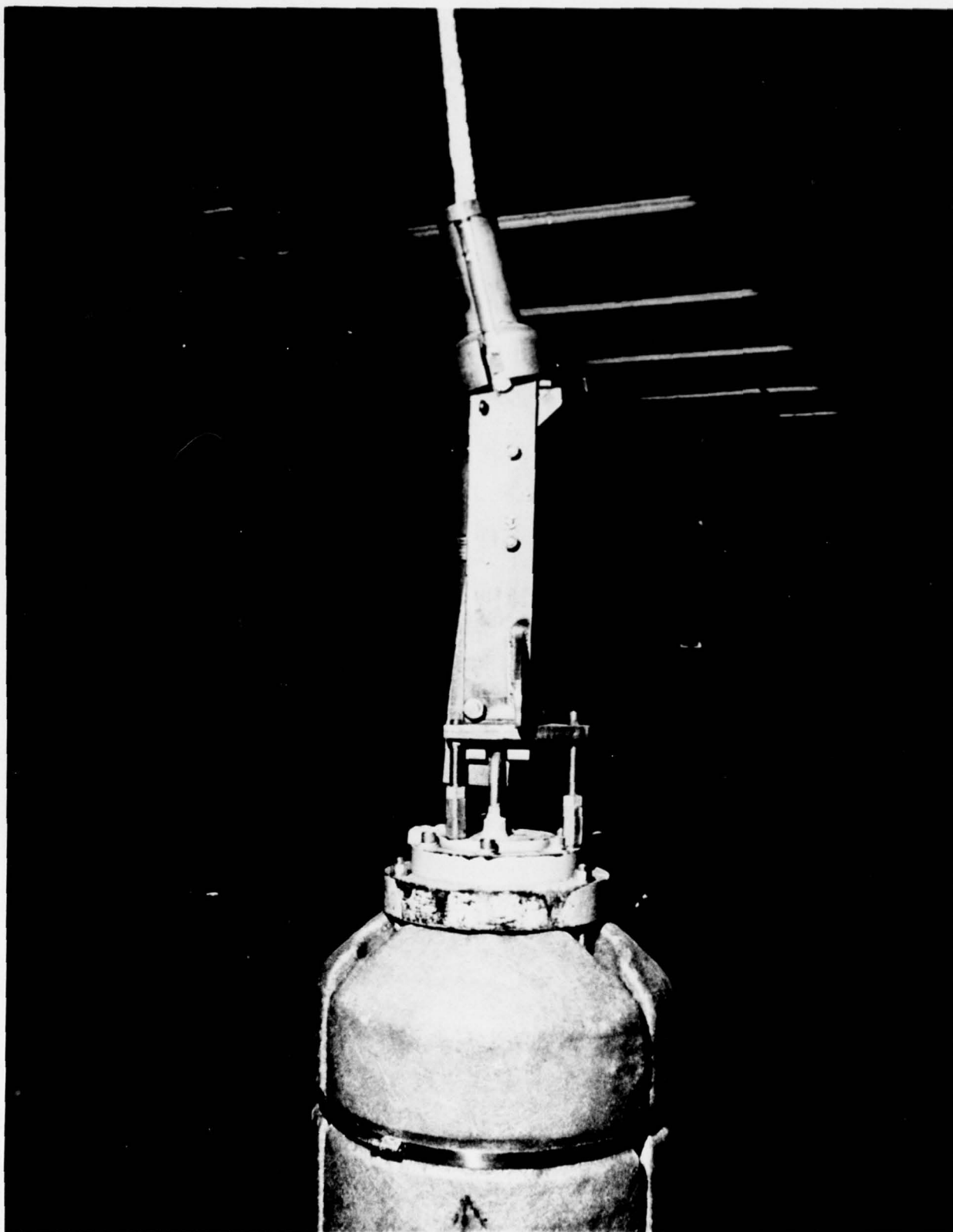


Figure 52 Trip Mechanism at Instant of Surface Messenger Contact

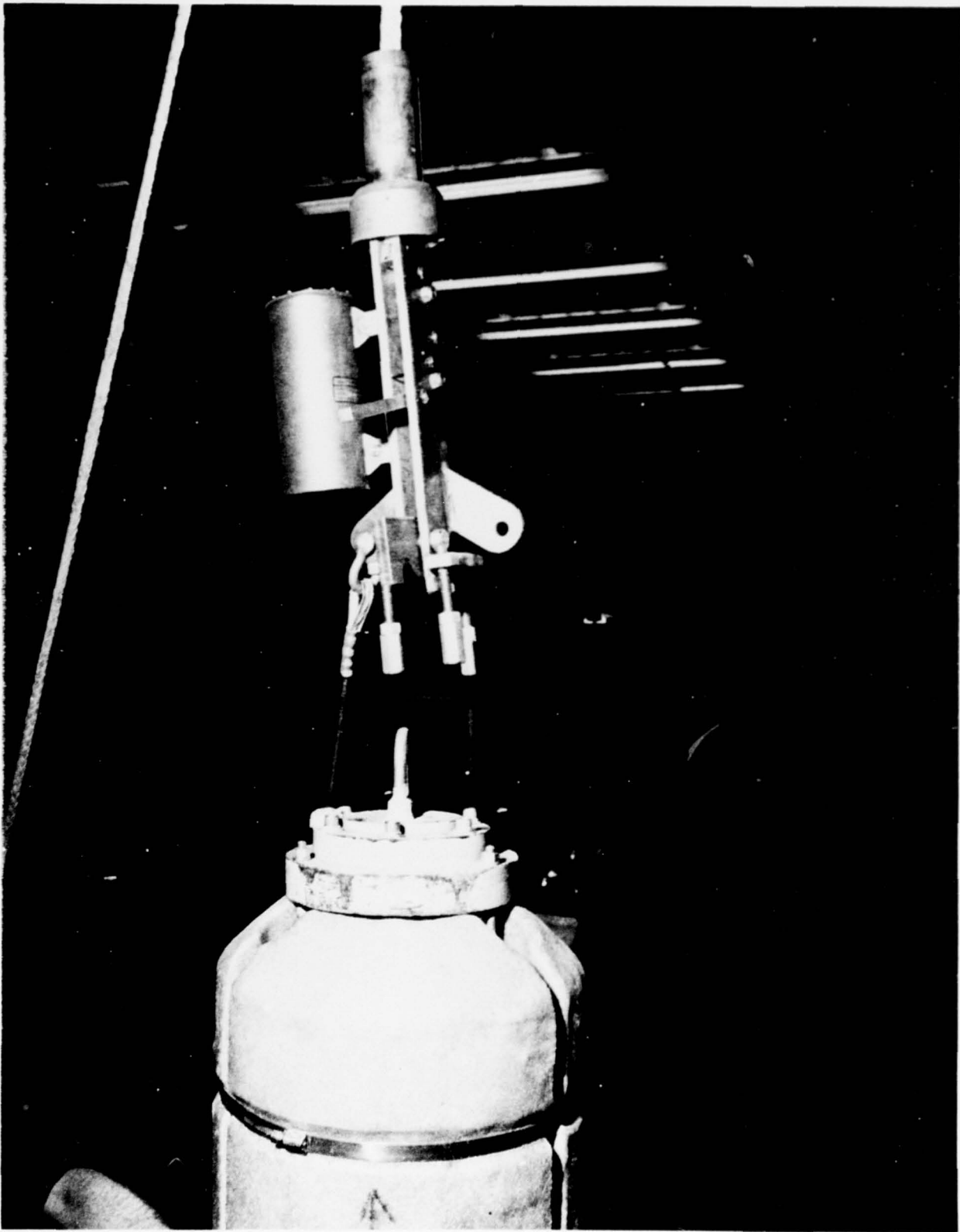


Figure 53 Trip in Release Condition, Starting Surface Recovery



Figure 54      Mechanical Release Trip Messenger, Open Position



Figure 55      Mechanical Release Trip Messenger, Locked Over Cable

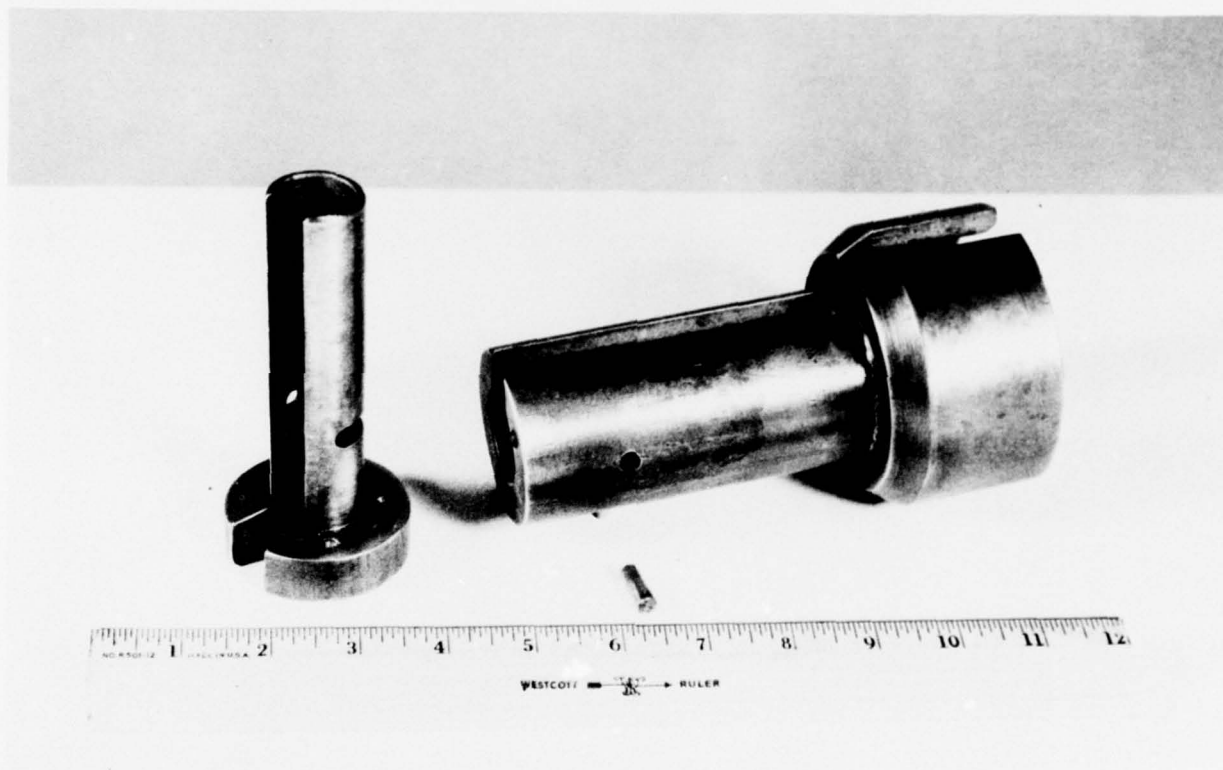


Figure 56 Exploded View of Line Messenger

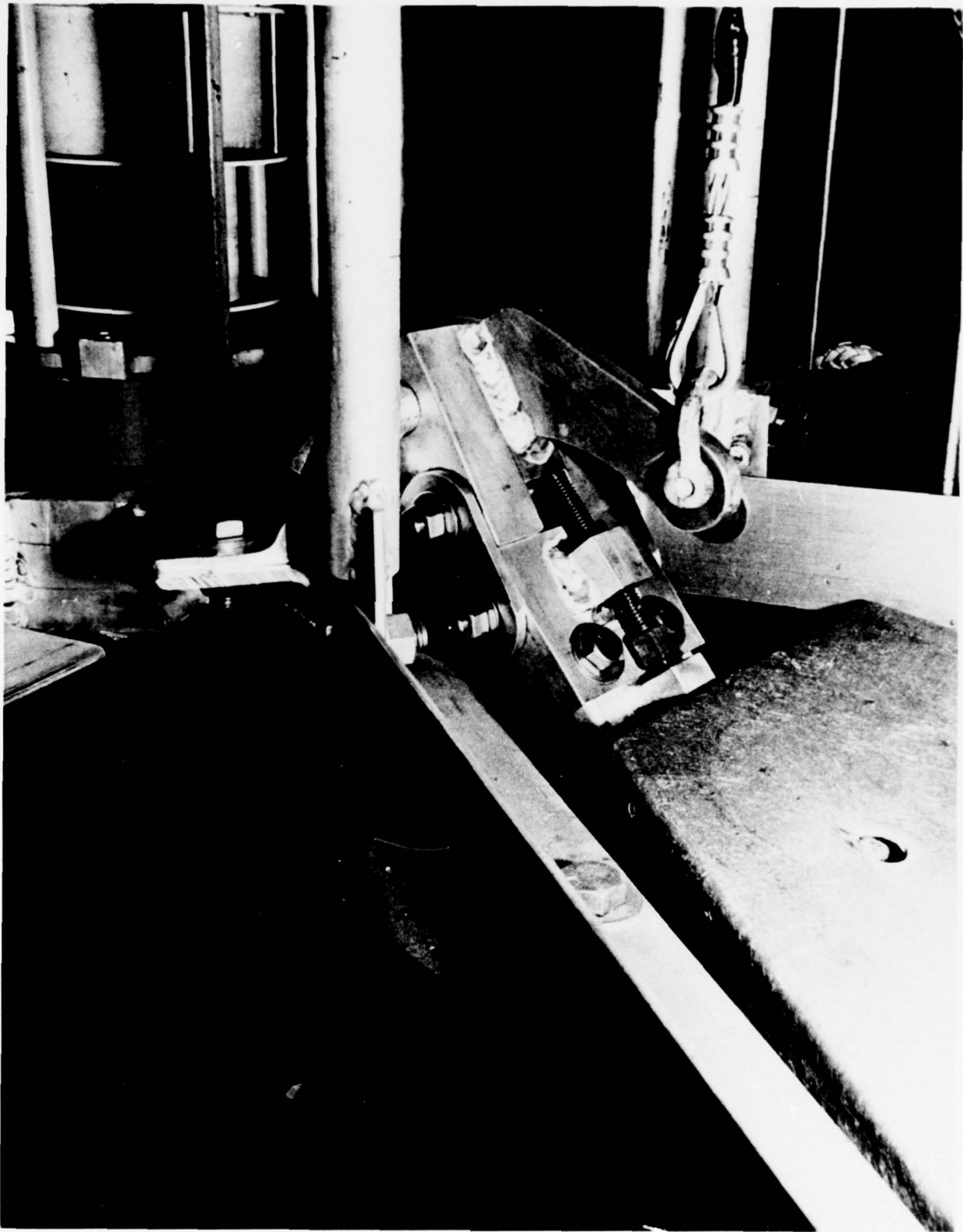


Figure 57 Over-Center Toggle Release Lock

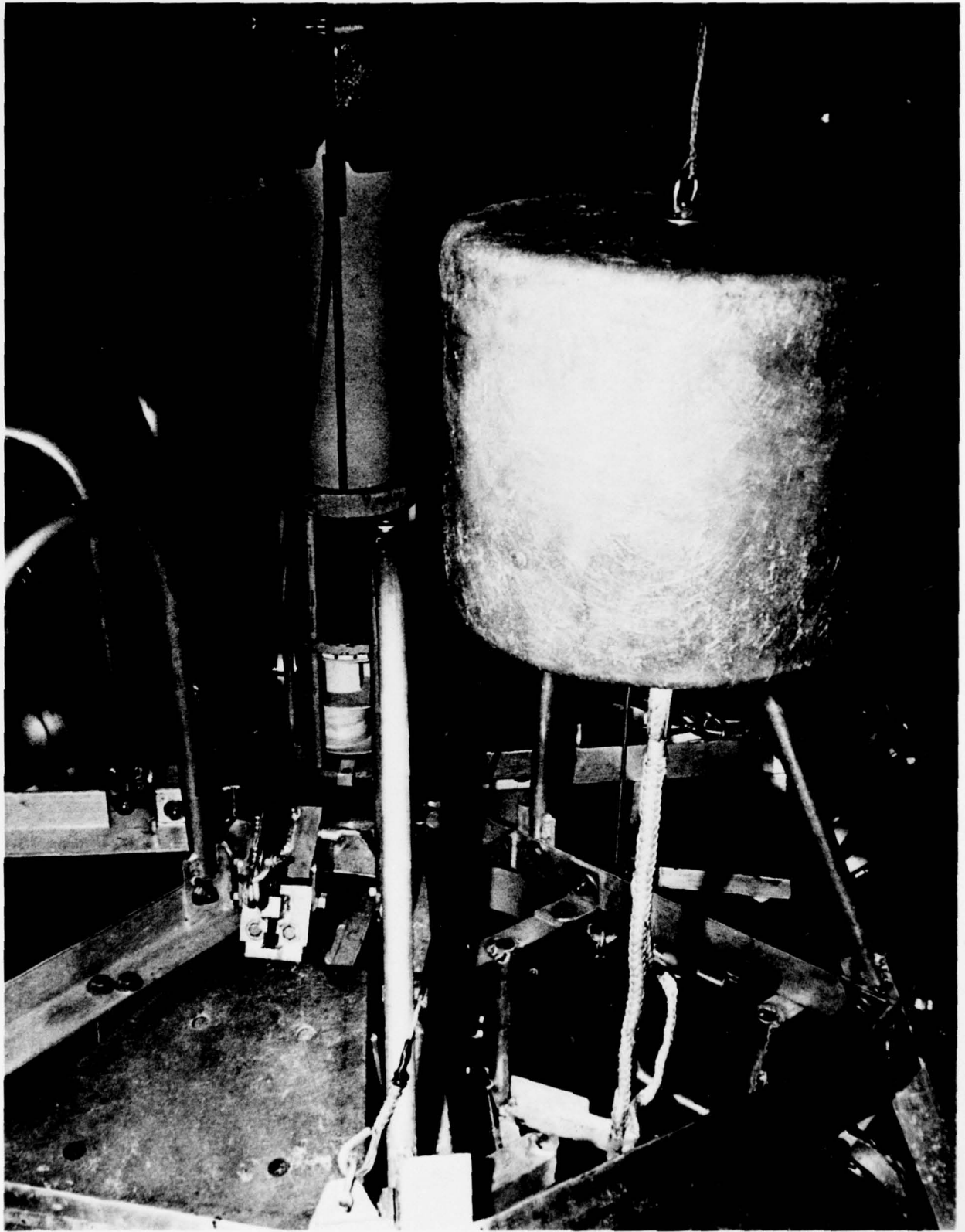


Figure 58 Over-Center Toggle Lock and Release Line

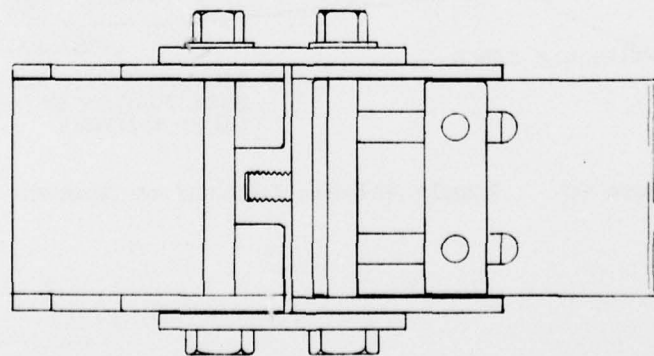
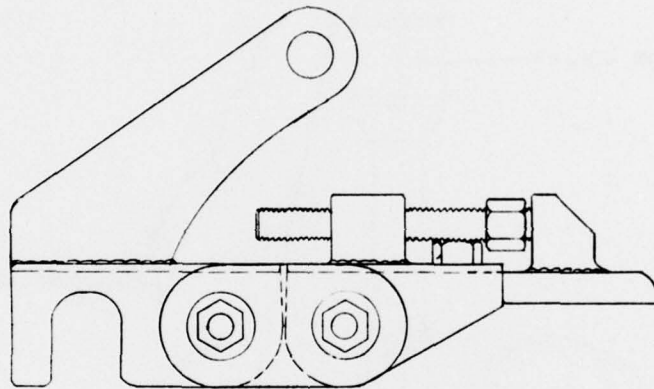
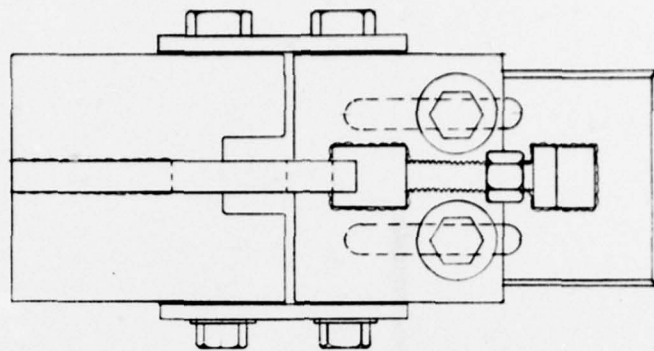


Figure 59 Toggle Release Sketch

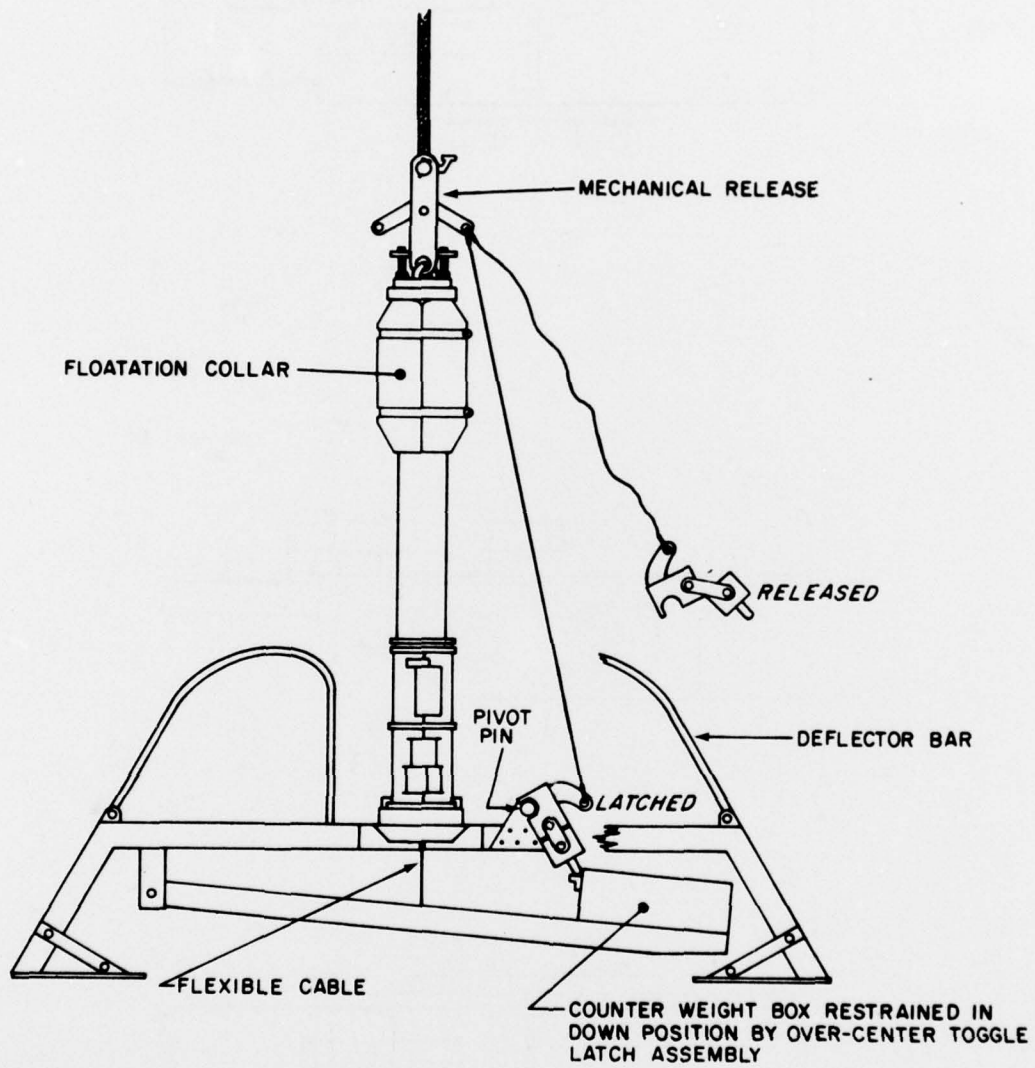


Figure 60 Toggle Release Latched on Counter Weight



Figure 61      Current Meter Floatation Collar



Figure 62      Current Meter on Forward Deck of Surface Support Vessel



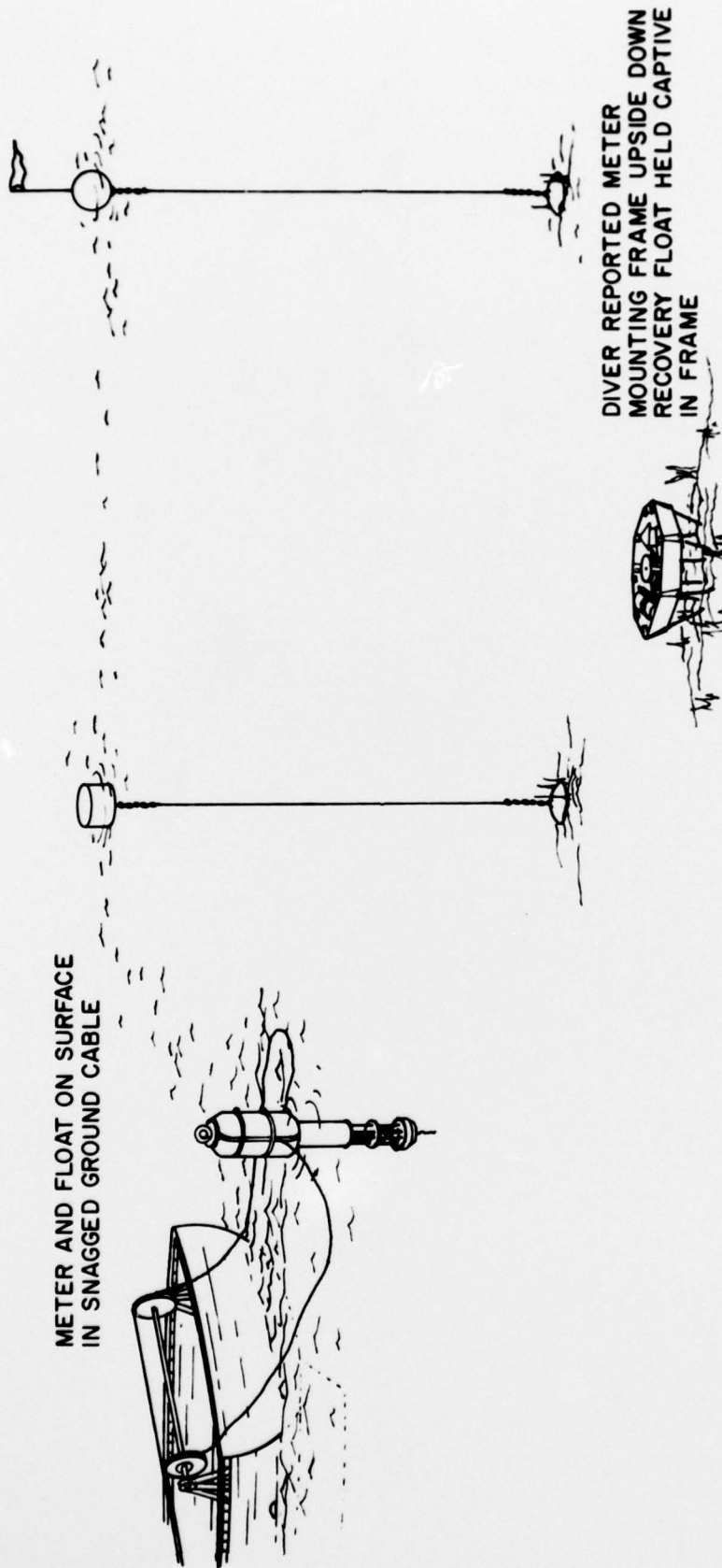


Figure 64 Artist Concept of Current Meter After Ground Cable Snag



Figure 65 Ground Cable Wedged Between Floatation Collar Segments



Figure 66 Severed Current Meter Hinge Cable

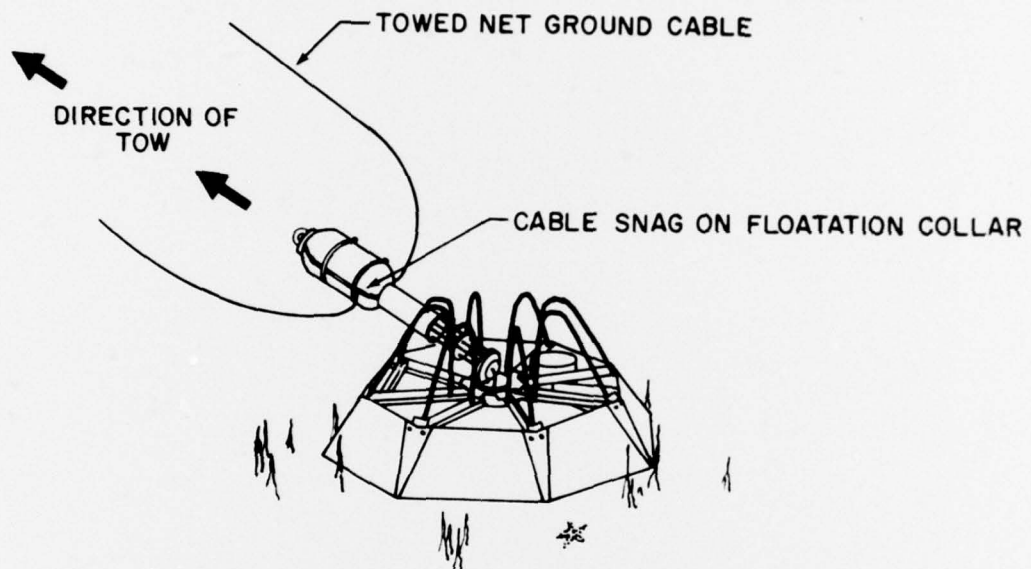


Figure 67     Artist Concept of Trawl Door Ground Cable Snag on Current Meter Floatation Collar

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The apparatus required for the measurement of these currents can be suspended beneath a moored surface buoy, lowered from a surface vessel and placed on the bottom, or attached to a pier or other substructure. Regardless of the method selected, each has deficiencies inherent to its particular design and installation.

A current measuring device mounted beneath a surface buoy can have induced meter motions that degrade the data, as well as drawing attention to the area, which in turn invites pilferage of the equipment. Current measuring devices that are lowered to the bottom usually require the use of a diver to assure proper orientation, and, if a surface buoy is used to mark the location of the instruments, it is again susceptible to possible theft.

In the event the meter assembly is positioned on the bottom by a surface vessel and the lowering line released from the instrument, it requires the use of a diver or grapnel hook assembly for the recovery. When using a grapnel as a means of attachment, there is a strong possibility of instrument damage or even loss if the bottom location is not precisely known by the surface personnel. If an acoustic release is used to recall the instrument package, the mooring frame work or anchoring system remains on the bottom and is lost.

The use of an unmarked bottom current measuring device, in addition to having recovery difficulties, is an unknown and unobserved target for nets and trawl lines being dragged across the bottom by commercial fishing vessels. As a result, the current measuring device may be severely damaged or never recovered if it becomes entangled in the fishing net.

In view of these difficulties, the design of a unique bottom mounted current meter mounting frame was initiated. The device provides some protection from nets and/or cables trailing behind a surface vessel fishing or dragging in the area. On deployment, and before release, it has the capability of relaying its vertical orientation to the surface operator. Through the use of a line messenger, the assembly can be mechanically released from the deployment line. It does not require an electrical power or instrumentation lead to relay vertical positioning or to accuate the release mechanism. On acoustic recall from a surface vessel, the assembly releases a float and lift line, providing a means of recovering the current meter and the mounting frame.

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The use of an unmarked bottom current measuring device, in addition to having recovery difficulties, is an unknown and unobserved target for nets and trawl lines being dragged across the bottom by commercial fishing vessels. As a result, the current measuring device may be severely damaged or never recovered if it becomes entangled in the fishing net.

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